Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Service Rules for Advanced Wireless Services in the 1915-1920 MHz, 1995-2000 MHz, 2020-2025 MHz and 2175-2180 MHz Bands	)	WT Docket No. 04-356
	)	
Service Rules for Advanced Wireless Services in the 1.7 GHz and 2.1 GHz Bands	)	WT Docket No. 02-353

COMMENTS OF NEXTEL COMMUNICATIONS

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SUMMARY

The Federal Communications Commission acted wisely when it allocated the 1915-1920 and 1995-2000 MHz to terrestrial mobile use. This band represents the last natural expansion band for personal communications services (PCS) service, and it offers incumbents and new entrants an enormous opportunity to enter new markets and improve customer service in existing ones. To ensure the H Block lives up to its promise, the Commission should establish the service rules necessary to make the 1915-1920 and 1995-2000 MHz compatible with PCS. The Commission's Part 24 rules provide prospective bidders enough flexibility to deploy an enormous variety of services while offering adjacent-band licensees the regulatory certainty necessary to allow them to continue to offer service to millions of customers without fear of harmful interference.

Although some operational limitations peculiar to H Block may be required, the Commission should reject attempts to needlessly constrain service offerings, limit eligibility, or restrict innovation in the newly available spectrum. The onerous limits that some competitors have proposed would raise costs, diminish competitiveness, and reduce investment – all with little or no appreciable gain in protection against interference. Only those rules minimally necessary to protect against harmful interference and to ensure successful deployment of services within the bands should be adopted.

Protecting the existing PCS bands requires no special technical constraints on H Block. The concerns raised by some in the PCS industry are contrary to longstanding industry practices, a rigorous probability analysis, and independent lab measurements. If the Commission nevertheless feels an additional out-of-band emissions (OOBE) protection of –60dBm/MHz is warranted for the H Block, then the Commission should require all PCS licensees to observe the same limit. An identical OOBE interference possibility exists from other PCS mobile stations as

from H Block mobile stations; therefore, failing to apply the same OOBE limit to H Block as to the other PCS bands would constitute arbitrary and capricious decision-making.

Nextel recognizes that reasonable technical limitations will be needed to ensure that MSS ATC and H Block licensees can coexist without harmful interference; however, the Commission should allow time for industry coordination to ensure that all parties receive protection. H Block licensees are just as likely to be victims of MSS ATC interference as they are sources of interference to MSS ATC. Because all parties share similar burdens and each will require some time to prepare for commercial operations, the parties are quite likely to come to an agreement on mutually acceptable solutions that permits both services to flourish. Immediate intervention in the nascent market at 1915-1920 MHz and 1995-2000 MHz might constrain the licensees' flexibility to develop negotiated solutions.

Service rules that promote economy and efficiency among licensees will best serve the public interest. The Commission should, therefore, license the H Block on a Basic Trading Area (BTA) basis to allow small and large businesses to acquire only the spectrum they need without having to incur the transaction costs associated with secondary markets. Similarly, the Commission should adopt simple and non-contingent rules governing relocation and reimbursement in the 1915-1920 MHz and 1995-2000 MHz bands. Introducing too many variables and contingencies into either the licensing areas or the relocation process will only serve to delay deployment, raise costs, and increase the likelihood of disputes.

To maximize economies of scale and minimize inefficiency, the Commission should also adopt rules to ensure that the H Block licensees generally observe the same commercial wireless service rules that other carriers do today. While no *ex ante* competitive restrictions are required, enforcement of any existing carrier-specific limitations on market entry remains essential to preserving an open market. Moreover, permitting designated entities to receive bidding credits will play an important role in strengthening the competitive market in this band. By adopting PCS rules for H Block, the Commission can enhance competition, accelerate investment, ensure diverse license holdings, and serve the public interest.

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COMMENTS OF NEXTEL COMMUNICATIONS

I. INTRODUCTION

Nextel Communications applauds the Commission's decision to expand competitive opportunities in the wireless communications marketplace by establishing two blocks of paired spectrum: (1) the 1915-1920/1995-2000 MHz block (the "H Block"); and (2) the 2020-2025/2175-2180 MHz block (the "J Block").[1] The Commission's decision to allocate the new H Block of paired spectrum at 1915-1920 MHz and 1995-2000 MHz for terrestrial mobile use reflects a victory of sound engineering practice over artificial, command-and-control limits on spectrum use. Licensing the H Block will help satisfy the enormous market demand for additional spectrum suitable for commercial wireless services and will allow the market to capitalize on new spectrum opportunities that will benefit all consumers.

Those who seek to impose onerous and unnecessary operational restrictions on the 1915-1920 MHz and 1995-2000 MHz bands should not be permitted to reverse the Commission's

[1] *Amendment of Part 2 of the Commission's Rules to Allocate Spectrum Below 3 GHz for Mobile and Fixed Services to Support the Introduction of New Advanced Wireless Services, including Third Generation Wireless Systems*, Sixth Report and Order, Third Memorandum Opinion and Order, and Fifth Memorandum Opinion and Order, ET Docket No. 00-258 (rel. Sept. 22, 2004) (*Allocation Order*). Unless otherwise specifically noted, these comments address the H Block of spectrum.

initial allocation decision in the instant proceeding. To ensure that the 1915-1920 MHz and 1995-2000 MHz bands are put to their highest valued use, the Commission should establish the licensing and service rules necessary to make these bands compatible with personal communications services (PCS). While some operational limitations may be necessary to protect against potential interference, the Commission should reject self-serving attempts to constrain service offerings, limit eligibility, exclude bidders from auction, or otherwise needlessly restrict entry into the newly available spectrum. The Commission should impose only those rules minimally necessary to protect against harmful interference and to ensure successful deployment of services within the bands.

II. THE COMMISSION SHOULD ADOPT A FLEXIBLE-USE REGULATORY FRAMEWORK FOR H BLOCK AND APPLY PART 24 RULES TO THE NEWLY ALLOCATED BAND.

In the *Service Rules Notice*, the Commission tentatively concluded that a "flexible use" framework for licensing these bands should apply.[2] Nextel supports the Commission's tentative conclusion and does not believe any additional restrictions beyond those minimally necessary to prevent interference are warranted. For example, the Commission proposed to permit licensees in these bands to provide all allowable services anywhere within their licensed area at any time, consistent with their regulatory status.[3] The Commission also proposed that applicants and licensees in the 1915-1920 MHz, 1995-2000 MHz, 2020-2025 MHz and 2175-2180 MHz bands

[2] *Service Rules for Advanced Wireless Services in the 1915-1920 MHz, 1995-2000 MHz, 2020-2025 MHz and 2175-2180 MHz Bands, Service Rules for Advanced Wireless Services in the 1.7 GHz and 2.1 GHz Bands*, Notice of Proposed Rulemaking, 19 FCC Rcd 19263, ¶ 13 (2004) (*Service Rules Notice*). The caption in this proceeding, *Service Rules for Advanced Wireless Services in the 1915-1920 MHz, 1995-2000 MHz, 2020-2025 MHz and 2175-2180 MHz Bands*, suggests that the Commission may have already reached a decision on whether to allocate the newly available spectrum for AWS or PCS use. To reflect the open inquiry as to whether Part 27 or Part 24 is the appropriate licensing regime in this case, Nextel refers to the *Allocation Order* and *Service Rules Notice*, rather than the *AWS Allocation Order* and *AWS Service Rules Notice.*

[3] *Service Rules Notice*, 19 FCC Rcd at ¶ 63.

indicate a regulatory status based on any services they choose to provide with enough flexibility to change that status on short notice if market circumstances change.[4] Nextel supports these proposals. As in other PCS bands, adopting a flexible-use allocation in this case will promote more efficient spectrum markets and serve the public interest by encouraging investment in new technologies and services.[5]

Consistent with the recommendations of the Spectrum Policy Task Force, licensees in the H Block should have a clear understanding of their rights and responsibilities.[6] In the *Service Rules Notice*, the Commission sought comment on whether to license the 1915-1920 MHz, 1995-2000 MHz, 2020-2025 MHz and 2175-2180 MHz bands under Part 27 (AWS) or Part 24 (PCS).[7] The Commission can increase regulatory certainty by regulating the 1915-1920/1995-2000 MHz band under Part 24 of its rules. The enormous latitude offered under the Commission's Part 24

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[4] *Id.* at ¶ 65. In addition, the Commission proposed that, if a licensee changes regulatory status, the licensee must provide thirty days advance notice to the Commission. The Commission also proposed that a change in a licensee's regulatory status would not require prior Commission authorization, provided the licensee was in compliance with the foreign ownership requirements of section 310(b) of the Communications Act that apply as a result of the change. *Id.*

[5] *See Principles for Reallocation of Spectrum to Encourage the Development of Telecommunications Technologies for the New Millennium,* Policy Statement, 14 FCC Rcd 19868, ¶9 (1999) (*Spectrum Policy Statement*) ("[f]lexible allocations may result in more efficient spectrum markets"); *Amendment of the Commission's Rules Regarding the 37.0-38.6 GHz and 38.6-40 GHz Bands,* Report and Order and Second Notice of Proposed Rulemaking, 12 FCC Rcd 18600, ¶ 26 (1997) (noting that flexible use allocations allow carriers to respond more quickly to consumer demands). For purposes of this pleading, the terms "PCS band" and "core PCS bands" refer to 1850-1915 MHz and 1930-1995 MHz bands that are used or scheduled to be used to provide personal communications services; as used here, the terms include the recently assigned "G Block" frequencies at 1910-1915 MHz and 1990-1995 MHz.

[6] Federal Communications Commission, *Spectrum Policy Task Force Report*, ET Docket 02-135, 3 (Nov. 15, 2002), *available at* <http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-228542A1.doc> (models incorporating greater flexibility "must be based on clear definitions of the rights and responsibilities, particularly with respect to interference and interference protection.")

[7] *Service Rules Notice*, 19 FCC Rcd at ¶ 14-16.

rules has provided enough flexibility to permit carriers to respond to customer demands for new and enhanced wireless services. At the same time, the Part 24 rules have offered licensees the regulatory certainty necessary to offer services to tens of millions of customers without the fear of dissimilar uses occupying the band. Expressly applying the PCS rules to H Block will treat like services alike, minimize interference potential to adjacent-band licensees, and eliminate duplicative and burdensome regulations.

Applying the PCS rules to H Block makes the most sense for three basic reasons. First, CMRS carriers are highly likely use H Block to complement and extend existing PCS networks using the same types of equipment that they use to provide service in the PCS bands. The H Block is located immediately adjacent to PCS bands and comprises the last remaining spectrum that could serve as a natural PCS expansion band. Aside from H Block, no other spectrum exists that would permit carriers to build on existing infrastructure investments in providing wireless services. Indeed, all other future commercial wireless allocations suitable for PCS use, including the J Block, will be located relatively far away from the existing PCS bands.

If the H Block is not deployed as PCS, the incumbent PCS licensees have only two choices for deploying additional wireless communications services. A licensee could strike out on its own in distant expansion bands without the benefit of the core PCS bands' existing infrastructure of towers suitable for roaming and without the network production economies that come from producing large volumes of similar handsets. Doing so, however, would increase the average total cost of providing service. Alternatively, a licensee could attempt to leverage the existing scale and scope economies of the core PCS bands by acquiring the additional equipment necessary to communicate with both the core PCS bands and the distant expansion bands, such as J Block. At present, however, integrating the additional equipment necessary for seamless roaming is likely to prove time consuming and would drive up the average unit cost of producing handsets and providing services. Operators can deploy H Block equipment with minor modifications to current PCS equipment; however, operators cannot deploy J Block equipment without going through the time-consuming process of developing new equipment for these distant bands. The additional time-to-market will prove costly for potential competitors. By licensing H Block as PCS, PCS licensees can serve their existing customers or offer new and expanded services quickly and efficiently.

Second, licensing H Block as a PCS service will also eliminate the costly effect of complying with two sets of rules. As the Commission noted, if the Commission applies Part 27 rules to H Block, a full-band transmitter that ranges from 1930 MHz to 2000 MHz would need to receive two separate equipment authorizations: one under Part 24 and another under Part 27.[8] Each of these separate authorizations would likely require separate RF radiation safety tests.[9] If the Commission licenses the H Block as something other than PCS, most industry participants will incur unnecessary administrative expenses that other market participants will not face. Because Part 24 of the rules already offer carriers an a great deal of freedom to choose the types of services they may offer to the public, what little additional flexibility available to licensees under Part 27 of the Commission's rules simply does not outweigh the increased costs of regulatory compliance with a separate silo of rules and limitations.

Third, licensing H Block as a PCS service will minimize the potential for interference to adjacent-band licensees. As the Spectrum Policy Task Force Report stated, "One of the challenges presented by permitting additional flexibility within assigned spectrum is the potential for incompatible adjacent systems."[10] The Spectrum Policy Task Force recommended that the

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[8] *Id.* at ¶ 16; *compare* 47 C.F.R. §§ 24.51, 24.52 *with id.* §§ 27.51, 27.52.

[9] *Service Rules Notice,* 19 FCC Rcd at ¶ 16.

[10] *Spectrum Policy Task Force Report* at 22.

Commission consider "making spectrum policy decisions encouraging like systems or devices to be grouped in spectrum 'neighborhoods' with like systems."[11] Nowhere is that advice more relevant than in the H Block where introducing a use incompatible with adjacent-band PCS could threaten harmful interference to existing communications networks with millions of customers. Permitting air-to-ground (ATG) operations in the H Block, for example, would introduce a harmful, incompatible use into the midst of the core PCS bands.[12] Prospective ATG frequencies would be immediately adjacent to incompatible "G Block" PCS operations, Mobile-Satellite Service (MSS) operations, and Unlicensed PCS (UPCS) devices and would generate harmful interference to these adjacent-band licensees.[13] ATG and allocations other than PCS would prove particularly damaging not only due to the enormous opportunity cost of using the last available contiguous spectrum in the PCS bands for something other than PCS, but also due to the real potential for adjacent-band interference that a totally dissimilar service would likely introduce into the existing PCS networks. In this case, it is not enough to simply adopt AWS rules and hope that compatible PCS services emerge in the band. The risk of harmful interference from introducing an incompatible use into the core PCS bands is simply too great.

If the Commission wants to increase flexibility for *all* PCS licensees, including those in H Block, it should license *all* PCS licensees as AWS; however, the Commission should not single out H Block licensees for special treatment under Part 27 of the Commission's rules because the burdens of complying with two separate rule parts outweigh the benefits of limited

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[11] *Id.*

[12] *See Service Rules Notice*, 19 FCC Rcd at ¶¶ 22, 29.

[13] *See, e.g.*, Letter from Trey Hanbury, Nextel Communications, to Marlene H. Dortch, Federal Communications Commission, WT Docket 03-103, Attach. 1 (filed Nov. 16, 2004), *available at* <http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6516882259> (describing how wideband air-to-ground operations will generate harmful interference into adjacent-band licensees). The term "G Block" refers to the conditionally assigned terrestrial mobile spectrum in the 1910-1915 MHz and 1990-1995 MHz bands.

additional flexibility. Alternatively, the Commission might consider granting the initial H Block licenses under the Part 24 PCS rules, but provide that the H Block licenses would become subject to analogous Part 27 rules upon grant of renewal. This staggered approach would avoid the costs of imposing duplicative Part 27 rules during the initial H Block deployment while minimizing restrictive limits over the long term. Unless AWS rules apply equally to all CMRS licensees or are applied only for second-generation H Block systems, however, uneconomic disparities will persist.

Carriers will most likely use H Block as an extension of the PCS bands because this band is the last remaining spectrum immediately contiguous to the core PCS bands. Regulating H Block under Part 24 simply recognizes this reality and offers prospective H Block licensees a measure of certainty about other possible uses of the band. By offering licensees a clear delineation of their rights and responsibilities, the Commission will increase investment and competition while decreasing the risk of interference that might come from introducing an incompatible use immediately adjacent to the core PCS bands. The H Block offers tremendous opportunities for increasing competition in the wireless services market. The Commission can ensure that consumer and carriers alike realize the enormous cost savings if it treats like services alike and adopts a regulatory framework for H Block that balances in-band flexibility with adjacent-band compatibility.

III. THE POTENTIAL FOR ADJACENT-BAND INTERFERENCE IS LIMITED AND CAN BE MANAGED WITH LITTLE REGULATORY INTERVENTION FROM THE COMMISSION BEYOND STANDARD COMMISSION RULES AND INDUSTRY BEST PRACTICES.

In the proceedings leading up to the Commission's *Allocation Order*, some concerns were raised that the very proximity of the H Block that holds such great competitive promise to the other PCS frequency blocks may result in harmful interference to incumbent PCS operators. As demonstrated in the *Allocation Order*, many of these concerns proved unrealistic and entirely disproportionate to the actual potential for interference. In the *Service Rules Notice*, the Commission sought comment on a variety of rules necessary to ensure that the nation can realize the promise of licensing the H Block spectrum for commercial wireless use while at the same time protecting incumbent licensees against the potential for interference.[14] The Commission began by recognizing that "Broadband PCS, which occupies the spectrum adjacent to the 1915-1920 and 1995-2000 MHz bands, has enjoyed its great success through the ongoing, cooperative efforts of PCS licensees and equipment manufacturers."[15] The Commission then stated its intention to apply "minimal rules" in the H Block on the assumption that operators will continue to cooperate in the design and operation of communications systems in the band.[16]

The Commission's call for regulatory restraint and industry cooperation is exactly the right approach for regulating the H Block. Congress has directed similar regulation for all CMRS licensees to encourage competition in the mobile telephony market.[17] The Commission, therefore, should reject attempts to needlessly constrain service offerings, limit eligibility, or restrict innovation in the newly available spectrum.

In this case, the potential for interference into adjacent band services is low. H Block licensees can use these frequencies today without creating harmful interference for incumbent licensees generally by observing the same operational constraints that apply to other licensees of PCS spectrum and cooperating with adjacent-band licensees. There are only four basic situations in which interference could reasonably be expected to occur. As shown in the diagram, the four scenarios are as follows: (1) H Block uplink to PCS uplinks; (2) H Block uplink to UPCS and

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[14] *See, e.g., Service Rules Notice*, 19 FCC Rcd at ¶ 82.

[15] *Id.* at ¶ 83.

[16] *Id.* at ¶ 83.

[17] *See Omnibus Budget Reconciliation Act of 1993*, Pub. L. No. 103-66, Title VI, § 6002(b), 107 Stat. 312, 392 (1993), *codified at* 47 U.S.C. § 332.

PCS downlinks; (3) H Block downlink to PCS downlinks; and (4) H Block downlink to MSS and MSS ATC uplinks.

Scenarios	H Block Allocation	Adjacent Bands
1	Uplink	PCS Uplinks
2	Uplink	UPCS PCS Downlinks
3	Downlink	PCS Downlinks
4	Downlink	MSS Uplinks MSS ATC Uplinks

None of the possible interference scenarios around H Block are new or unusual, and none of the scenarios should pose a problem for either new entrants or the incumbent licensees. Notably, two of the four scenarios involve the G Block, where Nextel may become the sole licensee of these bands in the United States should it accept the terms of the *800 MHz Order*.[18] As a potential victim licensee, Nextel has a keen interest in ensuring that H Block does not cause harmful interference to neighboring licensees. Rather than impose across-the-board restrictions on the H Block that would constrain system design, the Commission should follow its time-tested practice of relying on standard interference-abatement limits and industry best practices to resolve most interference concerns.

A. Imposing Standard Out-of-Band Emission and Power Limits on H Block Mobile Handsets Will Protect PCS Uplinks Below 1915 MHz and Unlicensed PCS (UPCS) Devices in the 1920-1930 MHz Band.

The Commission's *Service Rules Notice* concluded that H Block handsets must satisfy a 43+10log(P) dB limit at the upper and lower edges of the 1915-1920 MHz band.[19] Meeting the 43+10log(P) dB limit, the Commission found, would adequately protect PCS uplinks operating

[18] *See generally Improving Public Safety Communications in the 800 MHz Band*, Report and Order, Fourth Report and Order, Fourth Memorandum Opinion and Order, and Order, WT Docket 02-55, FCC No. 04-168, 19 FCC Rcd 14969 (2004) (*800 MHz Order*).

[19] *Service Rules Notice*, 19 FCC Rcd at ¶ 87. This holding brings the H Block mobile handset limits into line with the current PCS rules, which allow a maximum transmit power of a mobile station to be 2 watts EIRP with the out-of-the-band emission limit of 43+10log(P). *See* 47 C.R.R. §§ 24.232, 24.238.

below 1915 MHz band and unlicensed isochronous communications in the 1920-1930 MHz band from harmful interference.[20] Nextel supports the Commission's conclusions.

Imposing a 43+10log(P) dB limit on H Block handsets will protect PCS base stations below 1915 MHz and UPCS devices in the 1920-1930 MHz band. As the Commission noted, the H Block allocation at 1915-1920 MHz would operate in the same direction as the PCS allocation. As a result, the H Block uplink would look no different than any other PCS uplink in the 1850-1910 MHz band. The compatible duplexing between H Block and PCS will minimize any interference potential between H Block uplink/downlink and PCS uplink/downlink. By placing like uses together, limiting noise to 43+10log(P) dB, and limiting Effective Isotropic Radiated Power (EIRP) to two watts, an H Block uplink allocation will not cause harmful interference to PCS uplinks below 1915 or UPCS devices located in the 1920-1930 MHz band.[21]

By comparison, UPCS is not entitled to interference protections from licensed services. As the Commission stated in the *Service Rules Notice*, "Part 15 operators may not cause interference, and must accept interference from licensed systems."[22] Even if UPCS had not had

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[20] *Service Rules Notice*, 19 FCC Rcd at ¶¶ 87-88, 90 (concluding that "it should not be necessary to require transmitters operating in the 1915-1920 MHz band to comply with an [OOBE] limit that is more restrictive than our standard limit of 43 + 10logP dB" to protect PCS base stations and that "there will be no need to impose any special requirements on AWS licensees to protect operations in the 1920-1930 MHz Part 15 band").

[21] *Service Rules Notice*, 19 FCC Rcd at ¶¶ 87-88, 90. The Commission originally assigned UPCS the 1910-1930 MHz band, which placed UPCS adjacent to the band assigned to PCS C Block. No special protections were required to ensure PCS C Block mobile stations at the 1910 MHz band edge did not interfere with UPCS in the 1910-1930 MHz band. In the same way that UPCS and C Block PCS proved compatible at 1910 MHz band edge, UPCS and H Block PCS are compatible at the 1920 MHz band edge. Introducing H Block simply moves the UPCS-PCS border up to 1920 MHz. No OOBE and power limits are required to protect UPCS beyond those originally imposed on C Block licensees.

[22] *Service Rules Notice*, 19 FCC Rcd at ¶ 88. The Commission stated that the current UPCS allocation in 1920-1930 MHz is for unlicensed isochronous (*i.e.*, voice) communications under Part 15 rules, and Part 15 operators may not cause interference and must accept interference from licensed systems. *Id*.

to design its systems for years with licensed adjacent band operations in mind, therefore, UPCS cannot claim protection from or cause interference to licensed services. In any case, existing PCS base stations and UPCS devices services will not cause harmful interference into the H Block uplink because these operations will use the same emissions mask and power limit as proposed for the H Block uplink band at 1915-1920. Thus, neither PCS uplinks, nor UPCS should experience any unacceptable interference from the licensing of H Block as an additional PCS service.

B. Imposing Standard Out-of-Band Emission and Power Limits on H Block Base Stations in the 1995-2000 MHz Band Will Protect PCS Base Stations Below 1995 MHz.

The Commission tentatively concluded that requiring H Block base station transmissions in the 1995-2000 MHz band to meet the standard emissions limit of 43 + 10log P dB at the lower edge of the band would adequately protect PCS base stations below 1995 MHz.[23] Nextel agrees. The 1930-1995 MHz band is assigned for PCS downlink operations and, assuming the Commission adopts PCS-like rules for H Block base-station transmitters, both 1995-2000 MHz and the 1930-1995 MHz bands will operate in the same direction and be compatible with each other. Because the H Block will be no different than any other downlink band used for PCS services, applying a standard noise limit of 43+10log(P) and a standard power limit of 1640 watts EIRP to H Block base stations in the 1995-2000 MHz band will protect PCS base stations below 1995 MHz.[24]

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[23] *Id.* at ¶93.

[24] *See, e.g.,* 47 C.F.R. § 24.238(a) ("On any frequency outside a licensee's frequency block, the power of any emission shall be attenuated below the transmitter power (P) by at least 43 + 10 log (P) dB."); *id.* § 24.232(a) ("Base stations are limited to 1640 watts peak equivalent isotropically radiated power . . .").

C. Imposing Standard Out-of-Band Emission and Power Limits on H Block Mobile Handsets Will Protect PCS Downlinks from Both Out-of-Band-Emissions and Receiver Overload Interference.

As with any radio-transmitting device, the H Block mobile handsets will emit a certain amount of power outside of their assigned frequency band. These out-of-band emissions (OOBE) have the potential to cause interference to services operating in adjacent frequency bands. In the case of H Block, however, ten megahertz of spectrum separates the proposed H Block uplink in the 1915-1920 MHz band from the PCS downlinks above 1930 MHz. Despite the relatively large expanse of spectrum between the band edge for the H Block uplink and that of the PCS A Block downlink, concerns were nevertheless raised in the allocation proceeding about the potential H Block mobile handsets transmitting in the 1915-1920 MHz band to interfere with PCS handsets receiving in the 1930-1990 MHz band. In the *Service Rules Notice,* the Commission noted that the 43 + 10log(P) dB limit is the traditional OOBE limit that the Commission has successfully used to prevent mobile-to-base interference in other cases, but it sought comment on whether additional protections were necessary in this case.[25] The Commission requested test data and specific technical analyses in support of the OOBE limits commenters might recommend.

The technical discussion in the Appendices responds to these requests and provides a detailed demonstration that, when combined with industry best practices, imposing a 43 + 10log(P) dB limit on H Block handsets will adequately protect PCS downlinks above 1930 MHz against the possibility of mobile-to-mobile interference whether in the form of out-of-band emissions or receiver overload. For both OOBE and receiver overload interference, the technical discussion proceeds in two stages. First, the discussion examines current instances of mobile-to-mobile interference and concludes that the current interference environment demonstrates, if

[25] *Service Rules Notice*, 19 FCC Rcd at ¶¶ 90-91.

anything, *more* OOBE and receiver overload interference than H Block could ever be expected to produce. Second, the discussion scrutinizes claims that the limited potential for mobile-to-mobile interference requires unprecedented restrictions on H Block mobile handsets. The analysis concludes that the Commission's standard operating rules for PCS will protect adjacent-band licensees against harmful interference. Rather than codify a detailed technical limit into its rules, the Commission should simply follow its usual practice of directing licensees to attenuate power of any emission outside of the authorized operating frequency ranges below the standard 43 + 10log(P) dB limit. This standard limit will protect incumbent PCS licensees today while granting future H Block licensees the flexibility necessary to follow up-to-date industry standards governing precisely how to protect existing operations.[26] As the Commission has recognized, moreover, future design improvements will likely reduce the susceptibility of PCS to interference over time.[27]

[26] *See, e.g., 800 MHz Order*, 19 FCC Rcd at ¶ 103 (refraining from imposing mandatory, "across-the-board" limits on all licensees and holding that "licensees are the best stewards of interference abatement technology and are best capable of determining when and to what degree that technology must be applied"); *Service Rules for the 746-764 and 776-794 MHz Bands, and Revisions to Part 27 of the Commission's Rules; Carriage of the Transmissions of Digital Television Broadcast Stations; Advanced Television Systems and Their Impact upon the Existing Television Broadcast Service,* Second Memorandum Opinion and Order, 16 FCC Rcd 1239, ¶ 13 (2001) (*700 MHz Second Memorandum Opinion and Order*)(refusing to impose restrictions "to protect against potential interference scenarios that we believe are highly unlikely to occur" because these instances "can be readily addressed on a case-by-case basis" using historically followed coordination procedures that "require cooperation and accommodation" to resolve interference).

[27] *See, e.g., Flexibility for Delivery of Communications by Mobile Satellite Service Providers in the 2 GHz Band, the L-Band, and the 1.6/2.4 GHz Bands,* Report and Order and Further Notice of Proposed Rulemaking, 18 FCC Rcd 1962, ¶ 120 (2003) (*MSS ATC Order*) (recognizing that interference problems that may develop over time can be mitigated by future PCS handset design modifications and through a cooperative effort by PCS and MSS ATC licensees to resolve these issues). While not necessary to demonstrate that H Block will not cause harmful interference, the long history of, and continued prospects for, improved CMRS handsets should offer both carriers and the Commission additional comfort in the limited potential for harmful H Block interference to occur in the future.

1. Out-of-Band Emissions from H Block Mobile Handsets Are Highly Unlikely to Cause Harmful Interference and Standard Limits Will Protect Incumbent PCS Operations.

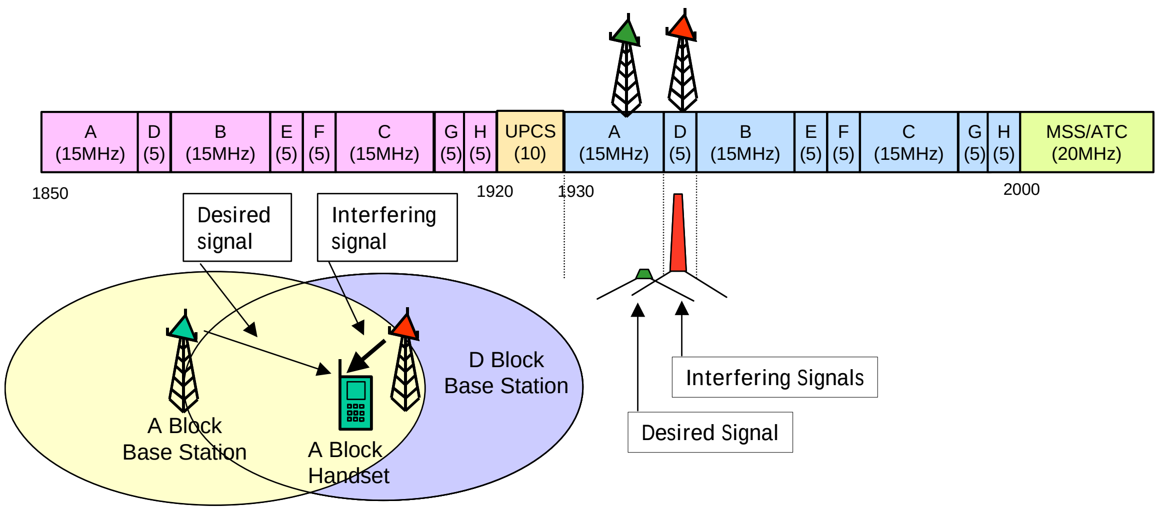
Out-of-band emissions from H Block into the PCS bands will not cause harmful interference to incumbent PCS licensees. First, existing PCS base stations produce hundreds of times more OOBE interference than H Block mobile handsets, yet existing PCS handsets compensate for these OOBE levels without difficulty. Second, built-in compensatory mechanisms – combined with the exceptionally low probability of two handsets being in close enough proximity to allow an H Block handset to cast OOBE into an incumbent PCS handset – permit H Block handsets to be licensed consistent with the existing Part 24 rules governing other PCS bands.

a. Real-world Interference-Mitigation Factors Permit Incumbent PCS Operators to Overcome Much More Interference Than Anything the H Block Mobile Handsets Could Produce.

Today, all PCS base stations transmit at much higher power than the relatively weak signals coming from PCS handsets. Under certain circumstances, a PCS licensee's mobile handsets will receive a weak signal from the desired base station and a much stronger undesired signal from the base stations of another PCS licensee. These circumstances can result in "near-far" interference, which is so named because the undesired signal is located relatively near the mobile handset while the desired signal is located relatively far away from the mobile handset.[28] The diagram below depicts an existing near-far interference scenario in the PCS bands. In this example, a PCS A Block licensee's base station is located at some distance away from the D

[28] Near-far interference is a common term that refers to any scenario where a receiver is far from the desired transmitter, but near an undesired transmitter. Near-far interference may result when a mobile station transmits at maximum power and interferes with undesired base station, or when the undesired base station's high transmit power interferes with mobile station's desired signal, or when a mobile station that belongs to the undesired base station and is in close proximity to the desired base station, which may create an identical interference mechanism.

Block licensee's base stations. The A Block mobile handset, which is shown in green in the diagram below, experiences near-far interference where the desired signal A Block base station signal produces a weak signal while the undesired D Block base station generates a strong signal.



Basic calculations for the resulting interference that an A Block mobile station receives from a D Block base station are shown in the table below. Although the Commission's rules prohibit PCS base stations from exceeding –13 dBm/MHz, the Commission's rules do not take into account antenna gains and losses that PCS signals experience. Using conservative assumptions for antenna effects, the effective OOBE level at the A Block edge is + 2 dBm/MHz EIRP. [29]

D Block Base Station Effective OOBE (dBm/MHz EIRP)	Distance Separation (Meters)	Free Space Path Loss	Victim handset antenna gain	Resulting Interference Level (dBm/MHz)	Receiver Noise Floor (dBm/MHz)	Noise rise over Receiver Noise Floor
-13 +17 -2 = +2	50 M	72 dB	-3 dB	-73	-174+60+8 = -106	33 dB
	100 M	78 dB		-79		27 dB
	200 M	84 dB		-85		21 dB

[29] Assuming 17 dBi antenna gain with 2 dB cable loss for PCS base stations, the effective OOBE limit of D Block base stations at the A Block edge becomes (-13 dBm/MHz + 17 dBi antenna gain – 2 dB cable loss) = +2 dBm/MHz EIRP. This calculation assumes 3 dB of antenna loss for the victim handset 8 dB of noise figure for the receiver noise floor calculation of mobile stations.

Once antenna gains and losses are taken into account, the undesired signal that a mobile handset must successfully tolerate today is quite significant. In the example above, when a mobile station is 200 meters away from an undesired base station antenna in an adjacent channel, the noise floor rise over the mobile station's receiver noise floor is **21 dB**. [30]

If mobile handsets today must overcome near-far interference on the order of 21 dB, it is highly unlikely that an increase of one, two, or three dB would result in harmful interference to incumbent PCS operations. In this proceeding, however, CTIA has claimed – with seemingly meticulous exactitude – that a total cumulative noise floor increase from H Block handsets of just 3 dB would reduce coverage by 35%, increase the number of cells by 111%, and increase total costs by 390%.[31] Either CTIA's claims about the effects of H Block OOBE are entirely fanciful, or the 21 to 33 dB increase in noise floor that PCS licensees observe *today* from other PCS licensee's base station within 200 meters of their operations would have long ago damaged the PCS industry beyond repair.

In reality, PCS licensees easily manage the existing 21 to 33 dB increase in the noise floor that base-to-mobile interference causes by relying on at least four important interference-mitigation factors. First, the interference-limited design of PCS networks provides robust coverage in cell borders. An interference-limited system incorporates a substantial amount of margin in the link budget necessary to establish points of communications between mobile handsets and base stations. For example, carriers commonly incorporate 10-20 dB of in-building penetration loss, 5-10 dB of fade margin, 3-5 dB of interference margin, and 3-8 dB of antenna/body loss. As a result, mobile stations rarely operate at the maximum sensitivity level

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[30] This interference mechanism is identical to the one that Nextel has been resolving in 800 MHz SMR band with public safety mobile stations.

[31] *See* Letter from Paul Garnett, CTIA – the Wireless Association, to Marlene H. Dortch, FCC, ET Docket 00-258, Attach. 1 at 7 (July 29, 2004).

necessary to become susceptible to interference in the first instance.[32] Second, a certain level of forward link power control allows PCS base stations to dynamically increase transmit power if additional power becomes necessary to overcome OOBE interference. The increased power coming from the base station greatly reduces the chance that a mobile handset will operate in maximum sensitivity mode, where it would become susceptible to OOBE interference. Third, different technologies provide additional system gain. For example, carriers commonly to include more than 3 dB of "soft handoff gain" in the forward link CDMA link budget. "Soft handoff gain" describes the gain achieved from the common situation where two or more of a carrier's towers provide coverage to the same geographic area.[33] Because one tower is almost always more powerful than the other when a mobile handset is positioned within range of two or more towers, the mobile handset is programmed to communicate with the stronger tower, rather than the weaker tower. By communicating with the stronger tower, the mobile handset does not operate at the maximum sensitivity level, which greatly reduces the potential for OOBE interference to other carriers.[34] Fourth, industry best practices, such as informally coordinating transmitter sites and antenna configurations among operators, allows PCS operators to manage the adjacent band OOBE interference without sweeping regulatory intervention from the

[32] As discussed further below, the CDMA Development Group conducted extensive tests in 2003 that indicate that a PCS mobile station transmits at the maximum power of 23 dBm for 0.19% of the time in urban topology and 1.81% of the time in suburban topology. *See* discussion *infra* § III(C)(2)(b) (citing CDMA Development Group, *CDG System Performance Tests*, Rev.3.0, CDG 35 (rel. April 9, 2003) (*CDMA Development Group Performance Test Analysis*)).

[33] To minimize the number of towers needed, an operator would ideally want to position all towers so that neither tower is more powerful than the other at the midpoint between the two towers. Due to siting restrictions and other factors, however, carriers rarely, if ever, can position towers so that power is exactly equal at the midpoint.

[34] In the case of CDMA systems, signals from multiple towers are combined, providing soft-handoff gain.

Commission.[35] The Commission long ago noted that cooperation among PCS licensees serves as the foundation for CMRS operations and added that "cellular operators have generally cooperated well with each other in coordinating their systems."[36] The same cooperative effort that permits current CMRS operations to operate successfully in the core PCS bands will permit H Block licensees to enter the H Block and compete. Taken together, these factors mitigate an enormous amount of OOBE interference today, and the Commission can count on these same factors to mitigate the much *lower* potential interference from H Block operations in the future.

b. Rather Than Codify a Detailed Technical Limit Into Rules, the Commission Should Simply Follow Its Usual Practice Of Directing Licensees to Attenuate Power of Any Emission Outside of The Authorized Operating Frequency Ranges Below –13 dBm/MHz.

In the *Service Rules Notice*, the Commission properly stopped short of seeking comment on the most onerous OOBE limits that some parties had proposed for H Block and questioned whether imposing –60 dBm/MHz at 1930 MHz as the OOBE limit at 1930 MHz was needed to protect the incumbent PCS mobile stations operating in 1930-1990 MHz band.[37]

Although the proposed threshold can be met, expressly incorporating an intrusive limit of –60 dBm/MHz into the Commission's rules is just as unnecessary in this case as it is in the service rules for every other PCS band. The table below compares potential H Block OOBE emissions to the actual OOBE emissions PCS licensees cause each other today. As discussed above, an existing PCS base stations can create substantial OOBE interference to mobile stations in an adjacent band. An undesired PCS base station in adjacent band with –13 dBm/MHz of

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[35] *See, e.g., Amendment of Parts 2 and 22 of the Commission's Rules to Permit Liberalization of Technology and Auxiliary Service Offerings in the Domestic Public Cellular Radio Telecommunications Service*, Report and Order, 7 FCC Rcd 7033, ¶ 27 (1988) (*Cellular Radio Order*) (citation omitted).

[36] *Id.*

[37] *Service Rules Notice*, 19 FCC Rcd at ¶ 91.

OOBE will raise the mobile station receiver noise floor by 21-33 dB when the mobile station is assumed to be 50-200 Meters away from the undesired base station transmitter. The following table summarizes the OOBE interference analysis with –60 dBm/MHz OOBE limit at 1930 MHz and compares the result with PCS base station OOBE interference case.

	OOBE level at 1930 MHz			PCS CDMA Base Station at adjacent band		
OOBElimit (dBm/MHz)	-60 dBm/MHz – 3dB antenna loss = -63 dBm/MHz			-13 dBm/MHz + 17dBi antenna gain – 2dB cable loss = +2		
Distance Separation (Meters)	1 M	2 M	5 M	50M	100M	200M
Free Space Path Loss	38 dB	44 dB	52 dB	72 dB	78 dB	84 dB
Receiving Mobile antenna gain	-3 dB			-3 dB		
OOBE power at victim handset's receiver	-104 dBm	-110 dBm	-118 dBm	-73 dBm	-79 dBm	-85 dBm
Receiver Noise Floor	-174 +10log(1MHz) + 8dB NF = -106 dBm/MHz					
Receiver Noise Floor Rise	2 dB	-4 dB	-12 dB	33 dB	27 dB	21 dB

Starting with the Commission's proposed OOBE limit of –60 dBm/MHz at 1930 MHz, 3 dB of antenna loss in the H Block mobile station generates an effective OOBE of –63 dBm/MHz at 1930 MHz.[38] With one meter of separation between the two mobile stations, free space path loss of 38 dB with antenna loss of 3 dB for the receiving antenna will cause 2 dB of receiver noise floor rise in the worst case scenario.

This small, worst-case rise in noise floor is extremely unlikely to happen in real world operations. First, as explained earlier, forward link power control and soft handoff gain in CDMA systems more than compensate for this mere 2 dB noise floor rise that might occur in the worst-case scenario of an H Block deployment. Built-in system configurations not only prevent OOBE from damaging other carriers operations as described above, but also will routinely

[38] The PCS industry commonly uses 3 dB of antenna loss for mobile stations, and the Commission has also assumed 3 dB of antenna loss in calculations contained in the *Allocation Order*. *See Allocation Order*, 19 FCC Rcd at ¶ 27 n.61.

remove two of the essential precursors for receiver overload interference – maximum sensitivity and maximum power – by reducing receiver sensitivity and boosting base station power. Second, the probability of a CDMA mobile station actually transmitting at the maximum power under any circumstances is extremely low. Recently, the CDMA Development Group (CDG) conducted a probability analysis that considered how often CDMA handsets would transmit at maximum power or, conversely, operate at maximum sensitivity in various environments.[39] Founded in 1993 as an international consortium of companies committed to the CDMA standard, the CDG is one of the world's leading organizations on CDMA operating standards. According to the CDG's study, *System Performance Tests*, the probability of a CDMA mobile station transmitting at the maximum power of 23 dBm at a given time is just **0.19%** based on urban topography as shown in the chart below.[40] In other words, **99.81%** of the time, one of the essential preconditions for H Block OOBE interference – PCS transmitters operating at maximum sensitivity in close proximity to another handset – will simply not exist in urban areas.[41] While in suburban areas the probability is slightly higher, mobile handsets operating in suburban locations are much less likely to be in close proximity of one another – another essential precondition for mobile-to-mobile interference to occur in the first place. [42] Thus,

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[39] *See* App. A: *CDMA Development Group Performance Test Analysis*. This document is reproduced with the consent of CDG.

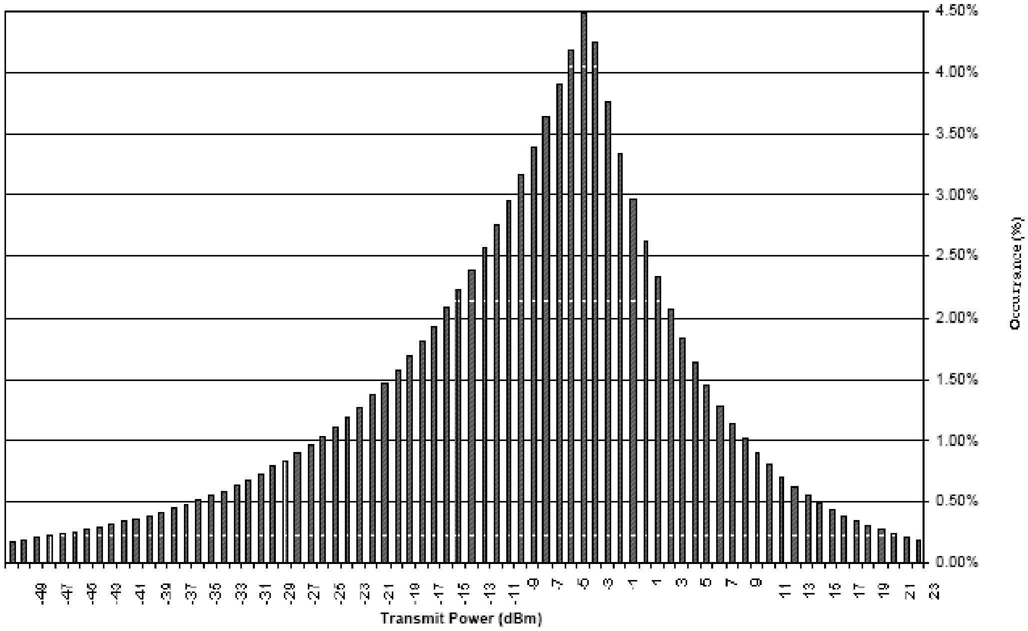
[40] *Id.* The statistical profile of mobile transmit power is based on actual drive tests in several deployed CDMA systems. This document has been widely used by CDMA handset manufacturers to estimate the current draw and battery performance of CDMA handsets. The stated purpose of these CDG tests was to provide "the CDMA community with a collection of standardized tests to objectively evaluate the performance of CDMA from an end-user perspective." *Id.* at vi.

[41] Because of the power-control mechanism, a CDMA handset transmits at maximum power when the received signal is at the maximum sensitivity level. Therefore, the probability of a CDMA handset operating in the receiver sensitivity level is 0.19% as well.

[42] In case of suburban topology, the probability of a CDMA mobile station to transmit at the maximum power increases to 1.81%. *Id.* at 2-5.

mobile handsets are highly unlikely to produce even the small worst-case rise in noise floor that allegedly would harm incumbent PCS operations.

Probability Distribution of Mobile Station Transmit Power (Urban Topography)
Source: CDG System Performance Tests Rev.3.0 CDG 35 (April 9, 2003)



Consistent with the OOBE limits that apply to every other PCS licensee, therefore, the Commission should establish an emissions limit at the authorized H Block channel border of –13 dBm/MHz (or, expressed differently, 43+10log(P)) at 1920 MHz. This limit at the authorized channel border, combined with the operators' voluntary compliance with evolving industry standards, adequately protects incumbents against potential interference today. Adopting the same limit for H Block licensees is a competitively neutral means of protecting incumbents PCS licensees against interference tomorrow.

If the Commission nevertheless believes a higher OOBE limit is required for H Block, then the same OOBE limit of –60dBm/MHz should apply to *all* PCS bands. Existing PCS base stations are far more likely to cause OOBE interference than a comparatively low-power H Block handset. Indeed, aside from companies gaming the regulatory system with the hope of imposing an anticompetitive restraint on H Block licensees, no reason exists to single out H

Block for onerous regulation. If like services are to be treated alike, then all PCS bands must operate under the same OOBE limits because all PCS bands are capable of producing the same levels and types of OOBE interference.

2. Mobile-to-mobile Receiver Overload Interference is Highly Unlikely to Occur and Standard Limits Will Protect Incumbent PCS Operations.

The Commission sought comments on potential power limitations on mobile stations operating in 1915-1920 MHz band due to receiver overload interference into the existing PCS mobile stations operating above 1930 MHz.[43] Nextel agrees with the Commission's conclusion that the mobile-to-mobile receiver overload interference is not significant when an H Block mobile transmits at 23 dBm.[44] As discussed in detail below, moreover, H Block mobile stations can transmit at higher power without causing any degradation to the existing PCS service quality as demonstrated in the following analysis.[45] Mobile-to-mobile interference can only occur if all of the following unlikely events happened simultaneously: the interfering mobile transmits at full power; and the victim mobile receives poor coverage; and both the victim and interfering mobile are simultaneously active; and both victim and interfering mobiles are in close proximity. To permit intensive spectrum use without causing interference to adjacent-band licensees, therefore, the Commission should adopt the current Part 24 rules governing the H Block mobile transmit power and let competition – not competitors – determine the services that carriers can offer in this band.

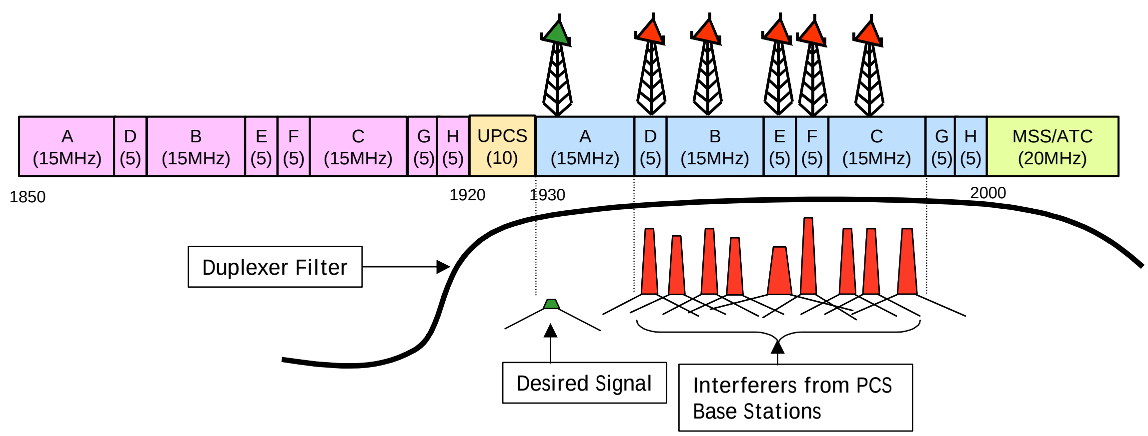
[43] Carriers sometimes refer to "receiver overload interference" as "RF overload interference." These terms refer to the same event. No difference in meaning is implied or intended. For consistency, only the term "receiver overload" is used in this document.

[44] *See Service Rules Notice*, 19 FCC Rcd at ¶ 27.

[45] While current voice-centric handsets are limited to the maximum transmit power of 23 dBm due to Specific Absorption Rate (SAR) requirements, future data devices will need to transmit at a higher power to enhance reverse-link performance.

a. **The Same Factors That Allow PCS Licensees to Manage the Existing Receiver Overload Interference from Undesired Base Station Signals Are More Than Adequate to Address the Much More Attenuated Potential for Receiver Overload Interference from H Block Mobile Stations.**

Today's PCS base stations cause receiver overload interference to PCS mobile handsets. Receiver overload occurs whenever the sheer power of another transmitter's signal overloads the victim receiver. As demonstrated in the figure below, today's PCS handset duplexers listen to signals spanning the entire 60 megahertz of the PCS downlink band from 1930-1990 MHz. This wide-open front-end receiver allows mobile handsets to roam among different compatible



networks and to achieve economies of scale in producing similar duplexers for hundreds of millions of handsets. The same, wide-open radiofrequency (RF) front end that permits seamless roaming and enables economies of scale, however, forces the PCS mobile station to receive all of the power transmitted from a PCS base station, both desired and undesired. PCS handsets that receive PCS signals from throughout the PCS band are susceptible to receiver overload interference from unwanted PCS base station signals. Within a distance of 200 meters, for example, unwanted PCS base station signals can overwhelm an operator's PCS handset receivers with receiver overload interference.[46]

[46] *See* discussion *supra* § 2.1.

The type of receiver-overload interference that PCS licensees experience today from other PCS licensee base stations is identical to the potential receiver-overload interference that an H Block mobile station might produce. A low noise amplifier (LNA) cannot and does not discriminate among the different sources of receiver overload interference. Therefore, whether the undesired signal power is coming from a mobile station, base station, or both, the aggregate total power that the LNA/Mixer sees is the only relevant factor in determining receiver overload interference. The following table summarizes the potential mobile station receiver overload interference calculation from undesired PCS base stations as it exists today.

Base Station Output Power per carrier (dBm/MHz EIRP)	Distance Separation (Meters)	Free Space Path Loss	Victim handset antenna gain	Resulting Interference Level (dBm/MHz)	Number of Carriers seen by mobile station	Total amount of undesired power seen by mobile station
43 +17-2 = +58	50 M	72 dB	-3 dB	-17	10log(10 carriers) = 10dB	-7 dBm
	100 M	78 dB		-23		-13 dBm
	200 M	84 dB		-29		-19 dBm

As indicated in the chart above, a CDMA base station in PCS band is assumed to transmit at 43 dBm (or 20 Watts) with a net antenna gain of 15 dBi, resulting in an EIRP value of 58 dBm/1.25MHz.[47] Assuming there are 10 CDMA equivalent carriers, the total amount of undesired signal power would become –7 dBm with 50 meters of separation and –13 dBm with 100 meters of separation. These interference estimates in today's PCS networks are conservative because a victim device is likely to see far more than a mere 10 CDMA carriers.[48] As carriers deploy broadband services and use the existing PCS allocations more intensively, a victim device

[47] The term dBi refers to "decibels relative to isotropic" and is used to define the gain of an antenna system relative to an isotropic radiator.

[48] For example, a single PCS A Block licensee can have as many as 10 CDMA carriers.

could soon see as many as 43 carriers in a 1.25 megahertz channel bandwidth for any given location.[49]

Even though PCS base stations emissions far exceed anything that an H Block handset could ever produce, CTIA has never proposed to limit incumbent PCS base stations' emissions to guard against the identical threat of receiver overload to PCS mobile handsets from PCS base stations. On the contrary, CTIA recently petitioned the Commission *to increase* the maximum transmit power limit of incumbent PCS base stations to 68 dBm/MHz (or 6560 Watts) for rural markets and 65 dBm (3280 Watts) for general markets.[50] If CTIA truly believed PCS mobile handsets were susceptible to receiver overload interference, CTIA presumably would not have proposed increasing the power of base stations because base stations pose a far greater potential for receiver overload interference than comparatively weak H Block mobile handsets. CTIA, however, supported increasing PCS base station power, stating that "the current EIRP limits for PCS licensees are too restrictive."[51] CTIA added that its proposals for increasing base station power should resolve concerns that "the current power limits hinder the development of new and innovative technologies that do not increase the potential for harmful interference to neighboring systems."[52]

CTIA and its member companies, including Nextel, supported increasing base station EIRP in the PCS bands not because they remained oblivious to the increased theoretical potential

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[49] This estimate of the number of carriers is derived by dividing the total available PCS spectrum, 60 MHz, by 1.25 MHz and then subtracting 5 block borders.

[50] Letter from Paul Garnett, CTIA – The Wireless Association, to Marlene H. Dortch, Federal Communications Commission, WT Docket 03-264 (filed Oct. 20, 2004), *available at* <http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6516750614>.

[51] *Id.*

[52] *Id.* at 2.

of higher power to result in greater potential receiver overload interference, but rather because they recognized that theoretical models of PCS deployment differ markedly from the real-world conditions in which mobile handsets actually operate.[53] Current CDMA handsets, for instance, offer variable LNA gain mode where the handset selects a different LNA gain depending on the desired signal's strength. When the desired signal is weak, the LNA uses a high-gain mode to maximize the amplification of desired signal and reduce the receiver overload protection. When the desired signal is strong, the LNA uses a low-gain mode to improve the receiver overload protection performance.[54] This variable LNA gain effectively minimizes the potential for receiver overload even when a handset confronts a signal as strong as -19 to -7 dB. In addition, existing "soft handoff" and "antenna diversity" gain techniques provide tools that operators use today to effectively manage receiver overload issues in existing PCS deployments. As the Commission has noted, moreover, cooperative efforts by licensees to resolve these issues have rather consistently proved capable of mitigating this type of interference among CMRS licensees.[55] Collectively, variable LNA gain, soft handoff gain, antenna diversity gain, and industry cooperation allow PCS incumbents to manage much more receiver overload

[53] Nextel, which is a member of CTIA, participated in the CTIA debate on this issue. Nextel supported CTIA's endorsement of raising output power limits because, like other CTIA members, it concluded that even persistent increases in PCS base station power limit was unlikely to affect PCS operations in any meaningful way, particularly in light of the long history of successful cooperation among carriers.

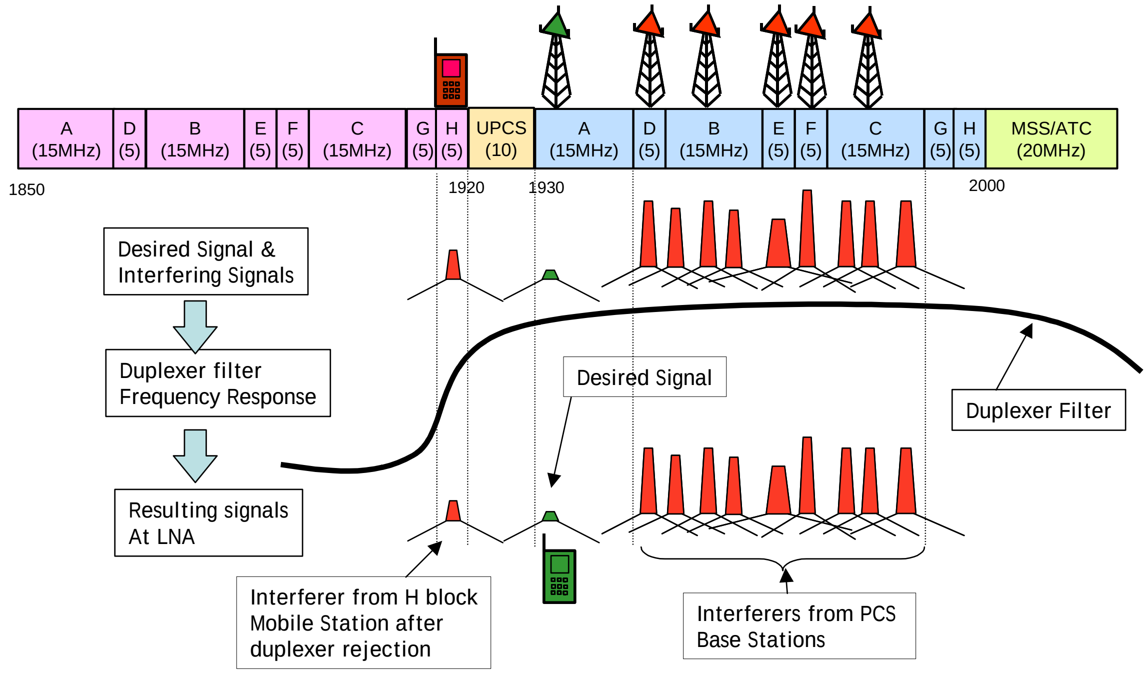
[54] If the desired signal level is sufficiently strong, sometimes the LNA is bypassed or the LNA acts as a signal attenuator to maximize the receiver overload protection.

[55] *See, e.g., 700 MHz Second Memorandum Opinion and Order*, 16 FCC Rcd at ¶ 13 (declining to adopt onerous limits that would preclude many services based on interference scenarios that were unlikely to occur and relying instead on "historically followed coordination procedures"); *Cellular Radio Order*, 7 FCC Rcd at ¶ 15-16, 26-27 (1988) ("Rather than implement a set of rigorous requirements that may over protect or under protect systems, we believe that instances of interference can best be handled on a case-by-case basis through the frequency coordination process. Cellular operators generally possess the technical expertise to perform appropriate analyses to limit the potential for interference between systems.").

interference today than anything that H Block might conceivably be capable of producing tomorrow.

Compared to the existing PCS base stations, the potential for receiver overload interference from H Block operations is no worse and, in fact, is significantly better than, the potential for receiver overload interference from incumbent PCS operations. As discussed above, an LNA cannot discriminate among desired and undesired signals. PCS LNAs remain open to all signals in the 1930-1990 MHz band whether wanted or unwanted. Thus, it makes no difference to the LNA whether the source of emissions is from a PCS base station or a mobile handset.

To place receiver overload interference in context with the existing receiver overload interference that all incumbent PCS base stations produce today, the diagram below depicts the interference mechanism for both H Block mobile station and undesired PCS base station signals. Despite the low probability of an H Block ever transmitting at maximum power in close proximity of the A Block handset, this condition is assumed for purposes of this example.



In this case, an A Block mobile handset experiences near-far interference where the desired signal is weak and an undesired base station is in close proximity. The PCS duplexer in the A Block mobile handset will accept all signals in the 1930-1990 MHz band with minimum insertion loss. For the H Block mobile station interferer, however, the duplexer will provide additional rejection.[56] The following table summarizes the resulting receiver-overload interference calculations that Nextel has made.[57]

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[56] The precise amount of rejection depends on the duplexer performance of a particular handset, as indicated in the measurements that Sprint conducted at an earlier stage of this proceeding. *See* Letter from Luisa L. Lancetti, Sprint, to Marlene Dortch, Federal Communications Commission, ET Docket 00-258, Attach. 1 at 9-11 (Sept. 1, 2004) (*Sprint Sept. 1 Ex Parte*), *available at* <http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6516482876>.

[57] For purposes of this example, the victim handset at A Block was assumed to have 10 dB of rejection performance for the H Block CDMA mobile station transmitting at 1918.75 MHz. The Sprint measurements on six duplexers indicated that the worst performing duplexer provides 10 dB of rejection and the best performing duplexer provided 30 dB of rejection at 1918.75 MHz at room temperature. *Sprint Sept. 1 Ex Parte*, Attach. 1 at 9.

	H block Mobile Station at 1918.75 MHz			Undesired Signal Level from other PCS Base Stations		
EIRP Transmit Power (dBm)	23dBm – 3dB antenna/body loss = **20dBm/1.25MHz**			43dBm + 17dBi antenna gain – 2dB cable loss + 10 carriers = **68dBm/1.25MHz**		
Distance Separation (Meters)	1 M	2 M	5 M	50M	100M	200M
Free Space Path Loss	38 dB	44 dB	52 dB	72 dB	78 dB	84 dB
Mobile Receiver antenna Gain	-3 dB			-3 dB		
Interfering signal power before duplexer	-22 dBm/1.25MHz			Same as after duplexer		
Duplexer Filter RX Rejection	10 dB			0 dB		
Interfering signal power after duplexer (dBm/1.25MHz)	-31	-37	-45	-7	-13	-19

Nextel's calculations in the table above demonstrate that much more severe receiver overload interference occurs when a victim mobile station is near an interfering base station than when an H Block mobile handset is in very close proximity to a PCS mobile handset. Indeed, the amount of interfering power from within the 200-meter radius of a PCS base station will range from ***12 to 38 dB stronger*** than the interfering power caused by H Block mobile station within one-meter of a PCS handset.[58] Lab measurements support this calculation. As demonstrated in the Appendix C, studies by Wireless Test Systems (WTS) show that receiver overload performance of existing PCS handsets is approximately 15-20 dB worse for an in-band interferer, such as a PCS base station, than for an H Block interferer.[59]

The enormous receiver-overload threat that PCS base stations pose *today* to PCS handsets in theory never materializes in fact because PCS systems are interference-limited systems with numerous built-in system protections, such as variable LNA gain, soft handoff, and antenna diversity designed to manage interference potential. The same tools and industry cooperation

[58] In this example, interfering power is measured just before the LNA of the victim PCS mobile station.

[59] Nextel believes that the additional duplexer filter rejection of current PCS handsets for the H Block interfering signals may explain why in-band signals, such as PCS base station emissions, cause far more harmful interference to PCS handsets than H Block signals would be capable of producing under worse case conditions.

that allow PCS licensees to cooperate and effectively manage the receiver overload interference from undesired base station signals are more than adequate to address the much more attenuated potential for receiver overload interference coming from H Block mobile station signals.

b. The Probability of Mobile-to-Mobile Interference Occurring Between H Block Mobile Handsets and Incumbent PCS Handsets is Exceptionally Low.

While receiver overload interference has been alleged, the parties raising these complaints uniformly fail to consider just how long the odds of mobile-to-mobile receiver overload occurring actually are. In authorizing new services, however, the Commission considers the actual probability of interference, not simply the harms that would exist if interference were to occur.[60] If the probability is low enough, the Commission will authorize the service despite the presence of possible harmful interference.[61] As explained below, harmful receiver overload interference does not exist in this case because both the PCS handsets and the H Block handsets will perform much better than has been alleged. Yet even if harmful interference were a consequence of licensing H Block operations, the exceptionally low probability that harm would ever occur indicates that the H Block can be licensed consistent with the existing PCS rules.

Nextel retained LCC International, Inc. (LCC), an independent expert on radiofrequency probability issues, to conduct a probability analysis of receiver overload interference between H Block and PCS mobile stations. LCC found that, even assuming always-on conditions that likely exaggerate the likelihood of occurrence, the probability of receiver-overload interference to the

[60] *See, e.g., MSS ATC Order*, 18 FCC Rcd at ¶ 120.

[61] *See, e.g., 700 MHz Memorandum Opinion and Order*, 16 FCC Rcd at ¶ 13 (declining to impose technical restrictions on services to protect against potential interference scenarios that the Commission found were highly unlikely to occur).

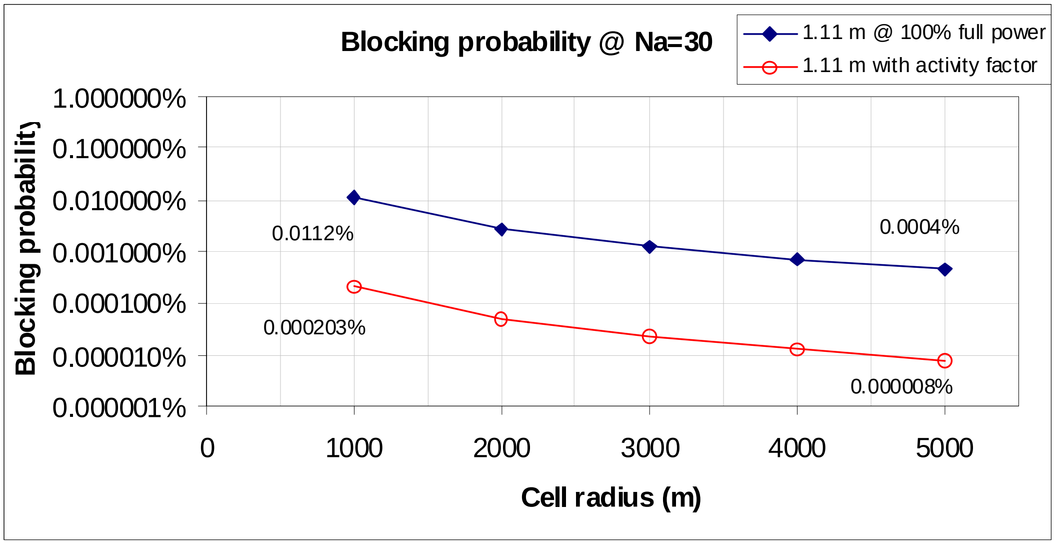
most vulnerable PCS mobile stations is little more than one one-hundredth of one percent.[62] Once LCC accounted for periods of inactivity, this inordinately low probability of occurrence dropped even further to approximately **two ten-thousandths of one percent**.[63]

To arrive at these conclusions, LCC tested two scenarios. In the first scenario, LCC assumed H Block handsets continuously transmit at a maximum power of 23 dBm and that Sprint is correct in asserting that the worst performing handset would experience 1 dB receiver overload interference at one meter separation distance.[64] LCC also assumed that H Block base stations and other PCS base stations were collocated, which creates the worst possible mobile-to-mobile interference scenario. LCC further assumed that 30 H Block end-users and 300 PCS end-users would simultaneously engage in conversation in the same sector and be uniformly distributed throughout the sector. In its study, LCC identified all H Block mobile station transmitting at 23 dBm by drawing a circle with radius of 1.1 meters to indicate a potential interference area. If LCC also found a PCS handset operating in the sensitivity level inside of this circle, LCC considered this area to be in "service outage" and the PCS handset to be blocked from communicating. As shown in the following chart, the probability of an H Block mobile handset actually causing an outage to a PCS handset is less than 0.0112% when H Block mobile stations are assumed to be transmitting all the time. This probability drops to 0.0002% when LCC used a standard activity factor for PCS handsets that more properly assumes that not all handsets are continuously engaged in calls.

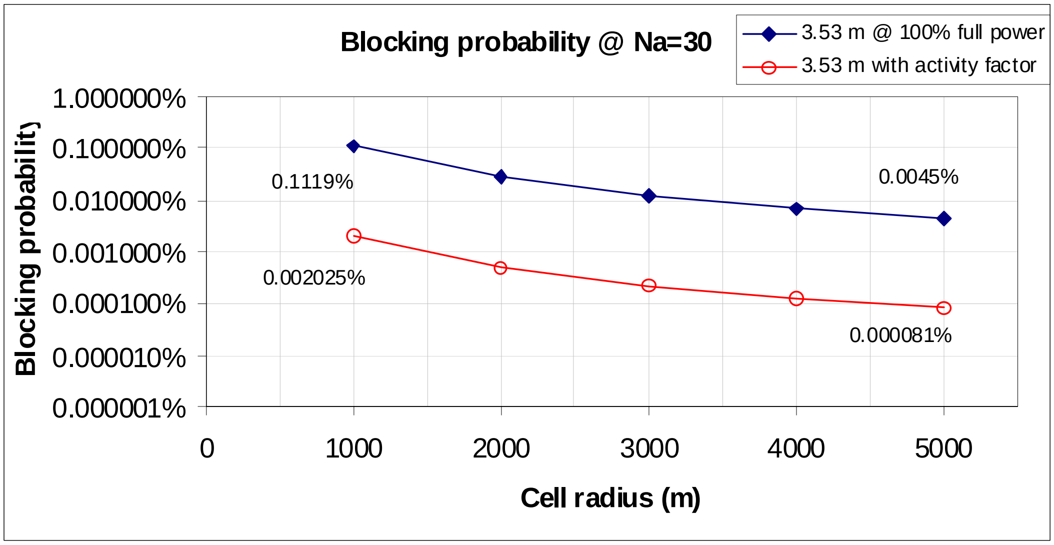
[62] *See infra* App. B at 7.

[63] *Id*.

[64] Consistent with the Sprint technical study, the LCC analysis also assumed that, if the distance separation were increased to 1.11 meters, an additional 1 dB of path loss would exist, which would effectively resolve the mobile-to-mobile interference issues.



In the second scenario, LCC assumed that an H Block mobile station transmitted at 33 dBm EIRP, which is the maximum allowed transmit power under Part 24 of the Commission's rules. To account for anticipated increases in distance separation among these higher-power devices, which could not be carried near a person's body due to federal SAR limitations, LCC increased the distance separation from 1.1 meters, which was used for the standard mobile handset, to 3.53 meters. Otherwise, LCC followed the same assumptions and simulation methodology in the second scenario as the first and concluded that the blocking probability for H Block mobile station transmitting at 33 dBm remains negligible as indicated in the chart below.



Based on LCC's extensive probability analysis, ample evidence exists to demonstrate that the receiver overload interference from H Block to PCS mobile stations has little chance of ever happening under any real-world circumstances outside of the PCS incumbents' laboratories. Competitors should not be permitted to constrain nascent H Block services based on negligible and hypothetical receiver overload concerns. Analysis simply does not support the highly speculative concerns about mobile-to-mobile receiver overload interference.

c. PCS Handsets Are Not as Susceptible to Receiver Overload Interference as the PCS Incumbents Claim.

Allegations concerning the susceptibility of incumbent PCS handsets to receiver overload interference also appear to be exaggerated. While Nextel has no major disagreement over the basic test methodology that Sprint used at an earlier stage of this proceeding, Sprint seems to have overstated the magnitude of receiver overload interference by testing a small subset of the poorly performing PCS handsets and by failing to consider the role that standard industry churn will play in eliminating any installed base of these poor-performing handsets.

To take the first of these factors into account, Nextel retained WTS, a CTIA-authorized test lab for CDMA handset certification that specializes in system testing, to conduct measurements of the susceptibility of incumbent handsets to receiver overload interference.[65] As described in detail in Appendix C, WTS conducted independent receiver overload lab measurements and found that the best-selling handsets perform significantly better than the handsets that Sprint previously tested. WTS tested eight PCS mobile handsets from four different manufacturers.[66] To remove any OOBE contributions from the CDMA signal generator positioned at 1918.75 MHz, which served as an H Block mobile station, WTS borrowed the identical band-pass filter used in Sprint's test setup from the Nokia Handset Group based in San Diego, California.[67] As shown in Appendix C, the test setup and test procedures were nearly identical to the Sprint test setup. The following chart summarizes the specific results of WTS's tests.

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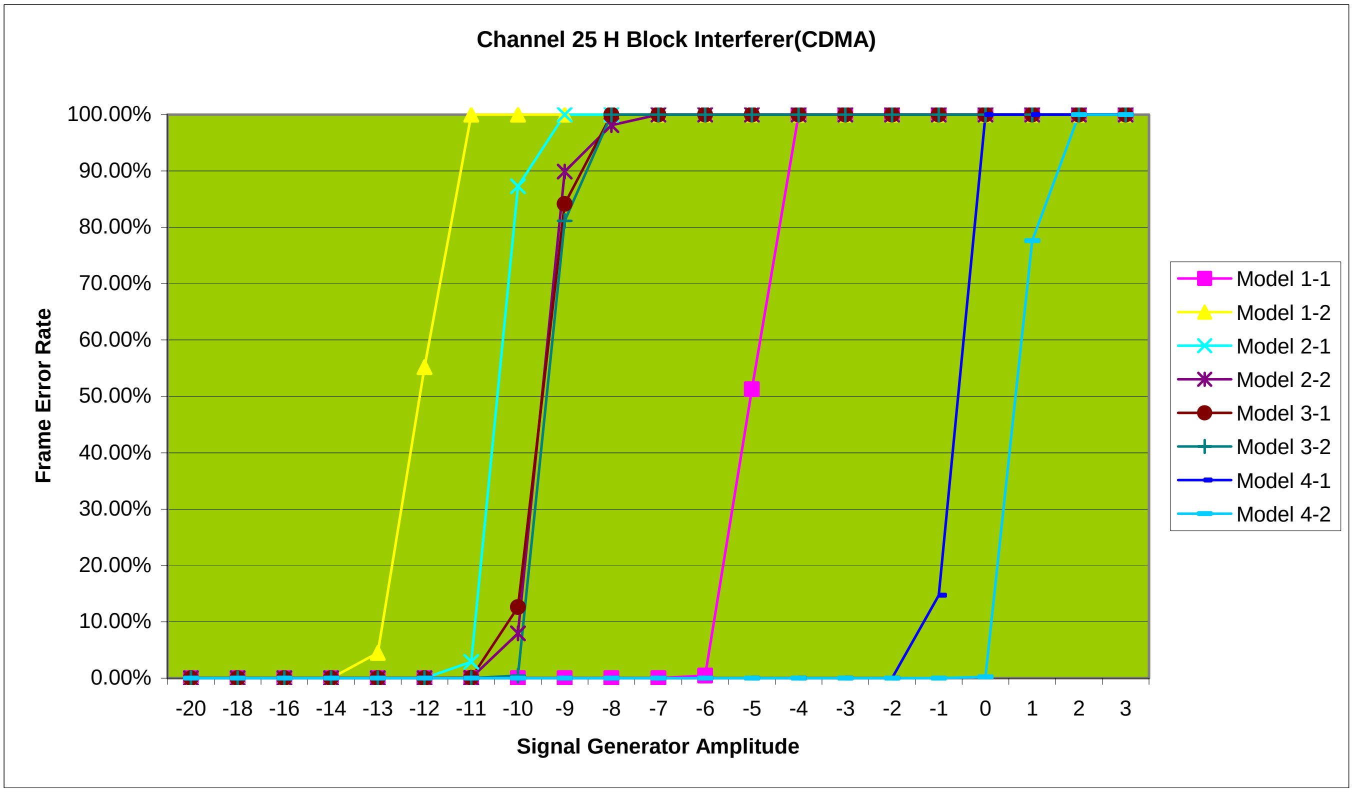
[65] *See infra* App. C. WTS develops automated test and verification software products for the wireless subscriber market concentrating on CDMA and other digital technologies. WTS has worked with leading CDMA subscriber terminal equipment developers and manufacturers to provide the most comprehensive automated CDMA verification platform on the market today.

[66] To conduct its tests, Nextel requested the best-selling handsets in the market today. It received best-selling handsets from two of the manufacturers and random models from the other two manufacturers. At the manufacturers' request, identifying information about the specific models tested has not been disclosed.

[67] Without this filter, Nextel realized that receiver overload measurement could not be performed due to increased noise floor by the CDMA signal generator in 1930-1990 MHz band. The Agilent ESG Signal Generator Model E4436B used in the test as an H Block interferer generated much higher OOBE interference such that receiver overload interference could not be measured. Using the same filter used in Sprint's measurement provided additional 40 dB of suppression on the Agilent signal generator and completely removed the OOBE contribution during the measurement.



While Sprint's measurement showed the worst performing mobile station can tolerate –22 dBm of received power from H Block mobile station transmitting at 1918.75 MHz, the independent WTS findings indicate that the worst performing handset can tolerate as much as –13 dBm of received power from an H Block mobile station. Similarly, the best performing handset from the WTS study was –5 dBm compared to Sprint's finding of +2 dBm. Compared to earlier assertions that the worst-case H Block mobile signal power to PCS mobile station receiver at one-meter separation was – 21 dBm, WTS's measurements demonstrate an additional 8 dB of margin exists on the maximum H Block mobile-station transmit power before receiver overload interference could occur even in the worst-case scenario.[68]

[68] WTS reached this result through the following calculation: 23 dBm transmit power – 3 dB antenna loss for H Block handset – 38 dB path loss with one meter separation – 3dB antenna loss for victim handset = -21 dBm. During the measurement, moreover, WTS could not get a consistent reading during the first few minutes of testing because the handsets under test were heating up as it transmits at the maximum power. All of these measurements were collected

Different handsets achieve different receiver overload performance due to many factors, yet one of the most important elements of performance is the type of duplexer filter used in the RF subsystem of a handset. Without understanding the detailed RF subsystem design specifications of existing handsets and the percentages of each type of handset on the market, precise measurements are difficult to establish. Yet by testing some of the best-selling handsets on the market today, WTS's study suggests that the majority of PCS handsets in the market perform much better than the worst performing handsets that Sprint tested in its study. Moreover, what AT&T Wireless has described as the PCS industry's "concerted efforts to maximize their use of spectrum ensure that receiver performance keeps pace with technological advancement" should ensure that receiver performance continues to improve.[69] The receiver overload "problem," in other words, appears to affect a small installed base of poorly designed handsets, rather than the most widely deployed handsets in the PCS industry.

The PCS carriers and CTIA have repeatedly urged the Commission to encourage licensees to raise their receiver performance standards to permit other carriers to operate when it benefits them.[70] In the 800 MHz proceeding, for example, CTIA and other PCS incumbents

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after allowing handsets to transmit at maximum power for five minutes such that the handset was operating at higher than room temperature. *See infra* App. B § 3.1.

[69] Comments of AT&T Wireless Services, ET Docket No. 03-65 at 10 (July 21, 2003).

[70] *See, e.g.,* Reply Comments of the Cellular Telecommunications & Internet Association, WT Docket 02-55 at 2 (Aug. 7, 2002) ("replacing legacy Public Safety radios is the most appropriate course of action to resolve the interference problem"); *id.* at 8 (noting that CTIA had convened a group of experts to advise public safety how to avoid interference and the group's two leading recommendations were to "1) initiate improvements in Public Safety handsets by adopting more rigorous testing standards for Public Safety equipment; 2) require Public Safety to adopt robust systems designs that take into consideration redundancy and margin of safety"); *id.* at 12 ("Public Safety needs to ensure that their mobile data systems are designed to operate in a strong signal environment"); Comments of Verizon Wireless, WT Docket 02-55, Declaration of William H. Stone, Jr., Executive Director Network Strategy for Verizon Wireless at 3 ("the potential for harmful interference can be greatly reduced by redesigning public safety networks, increasing the signal strength of the desired signal levels above local noise levels, and employing newer public safety receivers that are less susceptible

urged the Commission to direct public safety users "that they will be expected to deploy upgraded networking and receiver equipment designed to improve intermodulation rejection characteristics and achieve enhanced in-building coverage by a date certain in the future, and should begin immediately taking this into consideration when making purchasing decisions."[71] To the extent interference exists in some of the industry's worst performing handsets, PCS incumbents can more easily upgrade legacy equipment to prevent interference than the nation's public safety agencies could have. Yet now that parties other than the other PCS incumbents might actually benefit from limiting the susceptibility of receivers to interference, the PCS incumbents suddenly urge the Commission not only to tolerate outmoded receiver engineering, but also to constrain new services to protect a comparatively small number of commercial handsets that perform below industry norms.

Even if one accepts the PCS incumbents' expedient proposition that the PCS industry's worst performing handsets deserve extraordinary protection, only a small portion of the poorly performing handsets that Sprint has identified will be in the PCS networks in a few years. Sprint claims to have two million of one of these worst performing handsets in its network.[72] Depending on the age of these handsets, standard industry churn will eliminate these handsets from the market rapidly. Sprint experienced a monthly churn rate of approximately 2.7% as of the third quarter of 2004.[73] Assuming Sprint's churn rate remains at this level, only 14% of the

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to interference"); Comments of Verizon Wireless, WT Docket 02-55 at 9-10 (May 6, 2002) ("receiver overload and intermodulation interference, the two primary types of interference to public safety operations, cannot be significantly reduced unless the public safety receivers are designed to employ new RF filters that do not pass undesired signals").

[71] Comments of the Cellular Telecommunications & Internet Association, WT Docket 02-55 at 7-8 (May 6, 2002).

[72] *Sprint Sept. 1 Ex Parte,* Attach. 1 at 8.

[73] *See* Sprint, *Investor Update: Sprint Reports Third Quarter Results* 4 (Oct. 19, 2004), *available at* <http://www.sprint.com/sprint/ir/fn/qe.html>.

two million worst performing handsets will remain in the market in five years.[74] Even if Sprint did not add any new customers to its current base of 23.2 million PCS subscribers, the 282,334 worst performing handsets that would still remain in Sprint's handset deployment in five years would represent only an estimated 1.2% of the company's total 2004 handset base. Most important, none of these figures take into account the probability of these legacy handsets would actually experience interference. As discussed above, mobile-to-mobile interference is highly probabilistic and depends upon the coincident occurrence of four factors. When combined with just one factor – the 0.19% probability that PCS handsets will transmit at the maximum power in an urban topology – the resulting probability for Sprint's legacy handsets to experience receiver overload interference from H Block handsets would become just 0.000023%.

According to CTIA, "controlling interference and improving spectrum efficiency requires consideration of both the transmit and receive side of the ledger."[75] Nextel agrees. The remote possibility that legacy PCS handsets might experience interference should not be allowed to preclude new services, constrain competition, and stifle innovation.

D. Reasonable Limitations on some H Block Base Station Transmit Operations in the 1995-2000 MHz Band Will Protect Mobile-Satellite Service and Mobile-Satellite Service Ancillary Terrestrial Component Base Stations in the 2000-2020 MHz Band.

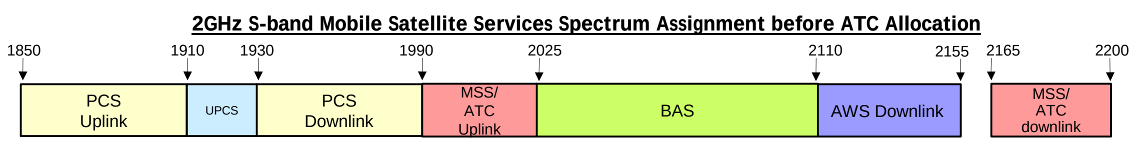
The Commission sought comment on how interference resulting from handsets operating within a given separation distance from MSS ATC mobile terminals might affect the overall

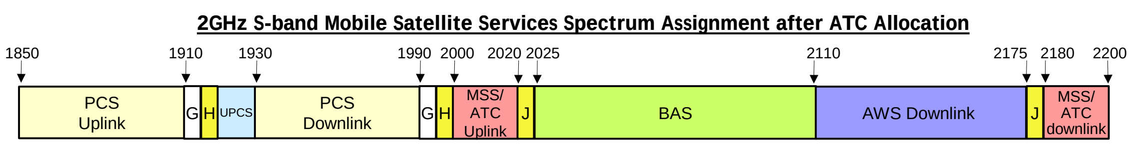
[74] Nextel recognizes that, to a certain extent, churn will affect both new handsets and older handsets and, thus, the potential speed at which handsets will be replaced could potentially be overstated by applying churn ratios year over year to the same subset of handsets. Although the precise rate at which churn will eliminate older handsets from the market might be debated, the basic point is that churn will rapidly diminish the installed base of poorly performing handsets over a relatively short period of time.

[75] Comments of the Cellular Telecommunications & Internet Association, ET Docket 03-65, 4 (July 21, 2003), *available at* <http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6514286617> (*CTIA Receiver Standard Comments*).

performance of H Block systems handsets in the 1995-2000 MHz band.[76] The Commission also asked for comment concerning whether base stations transmitting in the 1995-2000 MHz band might cause harmful interference to ATC base stations and MSS satellite receivers, and, if so, what measures might be needed to prevent both “receiver overload” and “out-of-band emission” interference.[77]

The interference mechanism between the MSS ATC bands and H Block is identical to the initial 2 GHz S-band MSS allocation and PCS C Block where 1990-2025 MHz was allocated for uplink (*i.e.*, earth-to-satellite) and the PCS C Block was adjacent to 1990 MHz as depicted below. Under the Part 24 rules, PCS base stations at 1990 MHz would transmit at the maximum power of 1640 watts (or 62 dBm) with OOBE limit of –13 dBm/MHz. These limits have not changed and MSS licensees should have taken the limits into account in designing their systems.





Detailed system design information of the currently licensed 2 GHz S-band MSS systems is not readily available and much of what has been put on file with the Commission does not specify exactly how the MSS systems will be deployed. Currently, five (5) licensed MSS systems are planned and these systems must share the 20 MHz of uplink spectrum, which results in 4 megahertz of MSS spectrum per system in each direction. These parties propose various technologies, including CDMA and TDMA, and, if implemented, MSS ATC will occupy a

[76] *Service Rules Notice*, 19 FCC Rcd at ¶ 97.

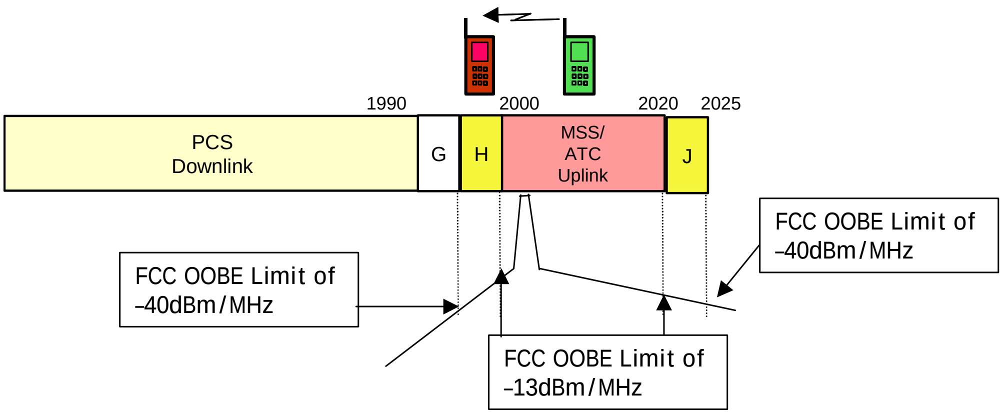
[77] *Id.* at ¶ 94.

certain portion of the spectrum. As discussed further below, Nextel recognizes that these systems, both space-based and terrestrially based, need protection from harmful interference.

While Nextel is still gathering information on the 2 GHz MSS satellite systems, particularly satellite receiver performance information, to determine precisely what protections might prove the most effective, the fundamental issues are discussed below. In each case, adjacent-band operations are likely to prove feasible with industry cooperation and minor limitations on service flexibility.

1. The Possibility of Interference from MSS ATC Mobile Stations into H Block Mobile Stations is Low.

In the *Service Rules Notice*, the Commission sought comment concerning the possibility of interference from MSS ATC mobile terminals to mobile terminals receiving in the 1995-2000 MHz band.[78] The Commission currently imposes a higher OOBE on MSS ATC handsets than it does on PCS handsets. Specifically in the *MSS ATC Order*, the Commission adopted 43+10log(P) (or, stated differently, –13 dBm/MHz) as the OOBE limit at 2000 MHz and 70+10log(P) or –40dBm/MHz at 1995 MHz, and then required linear interpolation between 1995 MHz and 2000 MHz as shown in the diagram below.[79] Due to the different OOBE standards



[78] *Id.*

[79] *Id.* at ¶ 96 & n.203 (citing 47 C.F.R. § 25.252(c)(2)).

involved and the absence of any separation between the MSS ATC mobile terminals above 2000 MHz and the H Block mobile terminals, the Commission sought comment in the instant proceeding concerning the potential for mobile-to-mobile interference from MSS ATC into the H Block.[80]

The potential for mobile-to-mobile OOBE interference is no greater at the 2000 MHz border than it is on the 1995 MHz border or the borders of the 800 MHz band. Mobile-to-mobile interference is highly probabilistic and rather unlikely to occur under any circumstances. In this case, moreover, OOBE interference will not meaningfully affect either MSS ATC or H Block customers. As indicated in the mobile-to-mobile interference analysis for H Block, built-in mitigation factors can manage the potential for interference.[81] In addition, parties can easily factor in the additional cost of interference mitigation, such as building additional margin into their link budgets, into their auction bids as a cost of doing business.

2. Operational Factors and Industry Coordination Can Mitigate the Potential for Interference Among H Block Base Stations and MSS ATC Base Stations.

The Commission sought comment on the effects of base-to-base interference between H Block base stations and MSS ATC base stations.[82] Nextel acknowledges that, without implementation of some interference-abatement measures, base-to-base interference with MSS ATC is possible. The transition between an uplink and a downlink band is difficult to negotiate and subject to potential adjacent-band interference. In this case, the 1995-2000 MHz band, which H Block licensees would use for downlink operations, is adjacent to the 2000-2020 MHz band, which MSS licensees may use for MSS ancillary terrestrial component (ATC) uplink

[80] *Id.* at ¶ 97.

[81] *See* discussion *supra* § III(C)(2).

[82] *Service Rules Notice*, 19 FCC Rcd at ¶ 95.

operations. If MSS licensees implement ATC networks, MSS ATC base station uplinks will require some measure of OOBE protection from H Block base-station downlink operations.

The Commission has properly held that many standard technical and operational factors can mitigate base-to-base interference.[83] In the *Service Rules Notice*, for example, the Commission noted that "licensees can 'down-tilt' their station antennas or locate their base stations far enough from one another, spectrally and geographically, to avoid interference."[84] Should interference concerns persist, the Commission added that mandating coordination among affected parties could effectively prevent base-to-base interference.[85] For its part, moreover, Nextel has a great deal of experience in preventing base-to-base interference from occurring in its existing 800-900 MHz operations. In the 800 MHz band, for example, only two megahertz separates the cellular base station receive band from the specialized mobile radio (SMR) base station transmit band. Nextel long ago recognized that its transmitters had the potential to create harmful OOBE to cellular licensees. Beginning in 1990s, therefore, Nextel installed a specialized filter that provided an additional 60 dB of rejection on each of its base stations simply as a cost of doing business to provide adequate rejection to protect cellular band receiver noise floor. Once Nextel deployed the specialized filter and began coordinating periodically with cellular licensees, interference from iDEN base stations has not affected cellular base-station performance. Given its successful experience in solving this type of interference potential between cellular and SMR operations, Nextel is confident that base-to-base interference between H Block base station and MSS ATC base station can be resolved.

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[83] *Id.* at ¶ 95.

[84] *Id.* at ¶ 95 n.202.

[85] *Id.* at ¶ 95.

Based on the current state of 2 GHz MSS deployments, however, it is not clear whether or how MSS licensees intend to deploy MSS ATC base stations and configure them within the band. Because of the uncertainty surrounding even the most basic factors of 2 GHz MSS ATC operations, including the number of 2 GHz S-band MSS licenses and their precise spectrum allocation within the 2 GHz MSS band, Nextel does not know which frequencies each licensee will use to deploy MSS ATC.[86] Despite the uncertainty over MSS ATC system deployments, Nextel continues to analyze various techniques to mitigate the potential for OOBE interference, including adopting tighter OOBE limits, using antenna polarization isolation, and implementing antenna, distance, and spectrum coordination measures to protect MSS ATC base stations. Depending on the precise configuration of the MSS ATC systems involved, some methods might be more practical, cost effective, and spectrum efficient than others. Although insufficient information exists to determine the optimum protection measures that the Commission should implement, Nextel commits to work in good faith with the MSS industry to establish a mutually satisfactory level of protection to any MSS ATC base stations that may ultimately be deployed.

3. Robust MSS System Design and Restrictions on Certain H Block Downlink Configurations Will Prevent Interference from H Block Downlink Operations from Harming MSS Receivers.

The Commission also sought comment about the possibility of interference from H Block downlinks in the 1995-2000 MHz generating interference to MSS satellite receivers in the 2000-2020 MHz band.[87] As a preliminary matter, neither OOBE interference, nor receiver-overload interference into the satellite receiver should cause harmful interference because MSS licensees should have designed their MSS systems with adjacent-band terrestrial base-stations emissions in

[86] Currently there are five licensees resulting 4+4 MHz of spectrum for each licensee. It is not clear how ATC will be deployed with 4+4 MHz of spectrum in terms of frequency assignment, technology and spectrum allocation for satellite versus the ATC system component.

[87] *Service Rules Notice*, 19 FCC Rcd at ¶ 94.

mind. Before the Commission reduced the size of the 2 GHz MSS band, the MSS uplink band was immediately adjacent to the C Block PCS band. While the Commission has since moved the MSS band edge to 2000 MHz, the H Block presents the same standard PCS operational characteristics as the C Block licensees did. The protections that MSS licensees implemented to avoid interference from C Block licensees will protect MSS licensees against H Block interference. If the MSS licensees adequately planned for adjacent-band terrestrial operations, their built-in system designs should adequately protect against most types of interference.

Putting aside the question of whether MSS licensees designed sufficiently robust systems, the potential for interference from H Block base stations to MSS satellite receivers depends upon many factors, including base station transmitter filtering, the maximum permissible level of interference allowed at the spacecraft receiver, the number of base stations interfering into an MSS spot beam, satellite receiver design specifications. As described fully in Appendix D, Comsearch studied these issues and concluded that adopting certain modest restrictions on H Block base stations and requiring proper satellite design would allow interference-free operation of both PCS operations in the 1995-2000 MHz band and MSS in the 2000-2020 MHz band.[88]

a. OOBE Interference from H Block Base Stations to MSS Satellite Receivers

Comsearch estimated the potential OOBE interference level by calculating the OOBE level at the spacecraft from one PCS base station and increasing this number by the worst case number of base stations within each spot beam that an MSS satellite produces. Comsearch compared Nextel's proposed iDEN-overlay PCS network deployment and assumed a 300-mile satellite spot beam contour. Under these assumptions, the worst-case base station density occurs around the New York area, which could contain as many as 5268 base stations. Based on

[88] *See infra* App. D at 1.

Commission OOBE limits, the table below describes the aggregate OOBE level for a GSO satellite system:

Single User OOBE Calculations		
Power (base station)	-13.0	dBm/MHz
Gain (base station)	-7.0	dBi[89]
Line losses	-2.0	DB
Free Space Loss to Sat	-190.0	DB
Gain (satellite receive)	43.0	DBi
Interference at Satellite	-169.0	dBm/1.00 MHz
Interference at Satellite	-259.0	dBW/Hz
Total Network OOB Calculations (Worst Case)		
Total number of Base Stations	15,804	5268 base stations x 3 for each sector
Converted to dB (10log(15804))	42.0	dB
Total Interference	-217.0	dBW/Hz
Interference Criteria	-213.8	dBW/Hz
Margin	3.2	dB

Because of conservative assumptions used in the calculation, the actual OOBE interference is expected to be better in a real-world deployment. In the simulation, the worst performing PCS base station antenna was used, all of the PCS base stations were assumed to transmit at full power simultaneously, and potential antenna polarization isolation was ignored. Based on these worst-case assumptions, however, Comsearch concluded that the Commission's OOBE limit of 43+10log(P) would protect satellite receivers from H Block PCS base stations.[90] Comsearch,

[89] The simulation calculated actual antenna gain from each antenna (sector); the weighted average for worst case in this cell was equal to –7 dBi. Additionally, four other antenna types were evaluated: (i) Andrew Corp DB910TCE-M Omni, EMS Wireless RR65-19-XXDPL5 65 degree sectored 18.5 dBi gain; (ii) EMS Wireless RR90-17-XXDPL2 90 degree sectored 16.5 dBi gain; (iii) EMS Wireless RR90-18-XXDP 90 degree sectored 17.5 dBi gain; and (iv) the Antel BXA-185063/8CF 63 degree sectored 18.5 dBi gain. All results for OOBE were within 3-4 dB of each other, *see* discussion *infra* App. D at § 8, Table 8), the Andrew DB932DG65E-M produced the most conservative results.

[90] *See infra* App. D at 18 ("OOBE should not pose a problem if the PCS base station transmitters meet or exceed the FCC Rule Part 24.238 limits").

moreover, validated the simple calculation above using proprietary interference-analysis software. Using Visualyze software, which is widely used in the satellite industry for modeling radio communication systems, Comsearch modeled both GSO and NGSO satellite constellations and incorporated the entire 20,000 base stations in sectors across the continental United States.[91] For the GSO case, the simulation result indicated that the worst-case aggregate OOBE level to satellite receiver would be –216.2 dBW/Hz, which is below the applicable interference criteria. For the NGSO case, the simulation indicated that the worst-case interference occurs when the main beam of H Block base station is pointing toward the NGSO satellite in the horizon and the level of aggregate OOBE level could be –207.8 dBW/Hz. While the estimated OOBE is worthy of additional investigation, it is not at all clear that licensees intend to deploy NGSO MSS systems in the 2 GHz MSS band due to the expense associated with NGSO systems.[92] In any case, Comsearch's simulation presents a worst-case scenario that does not consider any clutter factors or signal attenuation due to buildings, trees, and other obstacles. More detailed analysis is likely to show a reduced level of aggregate OOBE into NGSO satellite constellations.

Based on Comsearch's analysis and modeling, 5-10 dB of additional OOBE limitation will protect MSS satellite receivers against harmful interference. Whatever the exact protection needed for MSS satellite receivers, however, H Block licensees will already need to incorporate more than 10 dB of additional filtering into their base stations to protect terrestrially based MSS

[91] While the software is proprietary, Visualyse users include the Federal Communications Commission, the International Telecommunications Union, Boeing, Hughes, Lockheed Martin, Motorola, PanAmSat, and many others. *See generally* Visualyse, *Who Are Our Clients?*, *available at* <http://www.transfinite.com/transfinite_html/visworld_map_graphic.html> (last visited Dec. 2, 2004)

[92] New ICO is the only remaining 2 GHz MSS licensee proposing an NGSO system configuration in the 2 GHz MSS band. New ICO may not prove able to maintain its currently planned system configuration in light of the additional expense associated with constructing, launching, and operating NGSO satellite systems. To the best of Nextel's knowledge, moreover, New ICO has not chosen a Selected Assignment in the newly reconfigured 2000-2020 MHz MSS Uplink Band.

ATC base stations. Due to the additional measures that H Block base stations will need to implement to protect MSS ATC base stations, satellite receivers will not experience any OOBE interference from H Block base stations because distant satellites are far less susceptible to OOBE interference than MSS ATC base stations.

b. Receiver Overload Interference from the H Block Downlink to MSS Satellite Receivers

Comsearch also analyzed the potential for receiver overload interference from H Block downlinks in the 1995-2000 MHz band into MSS satellite receivers in the 2000-2020 MHz band.[93] To determine the MSS uplink receiver overload interference, details of the satellite design are necessary especially on the receiver RF subsystem such the maximum RF input/output levels without overdriving the LNA, the dynamic range of the LNA and the RF/IF filtering specifications. The critical factors for mitigating interference involve: (i) the RF receiver filtering at the spacecraft to protect the receiver from undesired out of the band signals; and (ii) the ability of the MSS receiver to reject adjacent-channel emissions to preclude system overload. The combination of antenna side-lobe suppression at the PCS base station, out-of-band rejection by the MSS spacecraft receivers, and the maximum saturated input power level specified at the spacecraft's receive LNA will determine the amount of allowed isolation between the services.

Considering an MSS mobile terminal uplink power of –12 dBW,[94] Comsearch calculated the dynamic range of the satellite receiver as –76 dBm.[95] Comsearch then calculated that the

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[93] *See infra* App. D at 15-18.

[94] *See infra* App. D at 16. The MSS mobile terminal uplink power defines how much receiver overload a satellite can tolerate because the satellite will receive signals from these MSS mobile stations. Assuming 23 dBm EIRP from a CDMA MSS mobile terminal, an additional 5 dB of fading loss is also considered. Terrestar made the same assumption at an earlier stage of this proceeding. *See* Letter from Jonathan D. Blake, Counsel for Terrestar Networks Inc., to Marlene Dortch, Secretary, Federal Communications Commission, ET Docket 00-258, IB Docket 99-81, Attach. 1 at 2 (filed Aug. 31, 2004) (*Terrestar Aug. 31, 2004 Ex Parte*),

total power level of H Block base station measured at the satellite would be –72.2 dBm – well within what MSS satellite receivers can tolerate. Comsearch's calculation of the aggregate amount of power from H Block PCS base station was based on a deployment of 20,000 H Block base stations nationwide, the same number as used in the OOBE analysis. Comsearch's assumptions are shown in the following table:

Overload Interference at MSS Spacecraft			
Free Space Loss:	190.5	dB	GSO satellite
LNA Input Saturation Level	-76	dBm	See Table 5, App. D (WTS study)
Total Power Level at S/C from PCS Base Stations	-72.2	dBm	Worst case cell derived from simulation
	Single User Level Uplink	***Fully Loaded User Level***	
Number of MSS Users	1	15,000	Conservative estimate of number of MSS MT users
MSS User Link EIRP (dBm)	18	59.8	Includes 5 dB of fade margin loss
MSS Level at input to Satellite LNA (dBm)	-129.5	-87.7	Without interference, from other MSS or adjacent band users, input to sat. LNAs are well below saturation
MSS + PCS Level into Satellite LNA (dBm)	-72.2	-72.1	Estimates PCS adjacent band interference to be well above aggregated operating point of MSS users
Margin	3.9	dB	Exceeds estimated value by 3.9 dB

While the simulation results indicate that there could be 3.9 dB of receiver overload interference from 20,000 H Block base stations based on the satellite receiver performance characteristics mentioned above, Comsearch's simulation results are very conservative. For example, Comsearch did not consider any mitigation factors, including:

- the use of base station antennas with better overhead gain suppression;
- the role of base station inactivity (not all base stations will be transmitting simultaneously);
- the improved performance of base station antennas with downward tilting antennas of greater than 2 degrees;
- the role of MSS satellite spot beams that have more off-axis roll-off than the basic model;

available at <http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6516482690>.

[95] *See infra* App. D. at 16.

- the likelihood of additional rejection due to MSS receiver filtering; and
- the function of antenna polarization isolation between PCS transmitters and MSS receivers.

With none of these mitigating factors taken into account, the worst-case scenario considerably overstates the actual levels that MSS satellite receivers would experience. While there could conceivably be marginal receiver overload interference from H Block base station to the satellite once these factors are considered, proper satellite design combined with other mitigation factors should alleviate any interference. Nextel will continue and expand discussions with satellite manufacturers to obtain accurate information on the satellite receiver design and, with MSS industry cooperation, conduct more detailed simulation to validate the practical impact to the satellite receivers from H Block base station. Depending on the results of these simulations and discussions, additional protections may be warranted.

IV. A BASIC TRADING AREA LICENSING ARRANGEMENT FOR THE 1915-1920/1995-2000 MHZ BAND WOULD MINIMIZE TRANSACTION COSTS, MAXIMIZE LICENSE VALUE, AND BEST SERVE THE PUBLIC INTEREST.

In the *Service Rules Notice*, the Commission tentatively concluded that it should license the designated bands using a geographic area-licensing scheme because geographic licensing "is better suited for the types of fixed and mobile services that will likely develop in these bands."[96] Nextel agrees with the Commission's tentative conclusion that licensing on a geographic service area basis will, as the Commission observed, provide important flexibility for licensees to respond to market demand, coordinate spectrum usage across wide areas, and maximize operational and administrative efficiencies.

The Commission also sought comment on the appropriate size of geographic service areas.[97] In setting service specific license areas, Section 309(j)(4)(C) of the Communications

[96] *Service Rules Notice*, 19 FCC Rcd at ¶18.

[97] *Id.* at ¶ 24.

Act directs the Commission to designate license service areas "that promote (i) an equitable distribution of licenses and services among geographic areas, (ii) economic opportunity for a wide variety of applicants, including small businesses, rural telephone companies, and businesses owned by members of minority groups and women, and (iii) investment in and rapid deployment of new technologies and services."[98] In the case of H Block, the geographic service area that best meets these goals is the Basic Trading Area (BTA).[99]

Defined by aggregating groups of counties that surround major cities, BTAs track CMRS licensees' typical customer-service areas. As the Commission has observed, BTAs "represent the natural flow of commerce, comprising areas within which consumers have a community of interest."[100] In this case, BTAs are both large enough to allow licensees to achieve economies of scale in service deployments and small enough to ensure that a diverse pool of service providers – including small, rural, and minority-owned businesses – can enter the market and deploy wide

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[98] 47 U.S.C. § 309(j)(4)(C).

[99] While Rand McNally & Company (Rand McNally) is the copyright owner of the BTA listings, Rand McNally has already licensed use of the BTA concept to the Commission in many radio services, including PCS. *See Service Rules Notice*, 19 FCC Rcd at 24 n.53; *Copyright Liabilities*, Public Notice, 11 FCC Rcd 22429 (Mass Media Bur., 1996). The existence of a BTA license for PCS supports licensing new, H Block services as <u>PCS</u> as opposed to some other type of service. As the Commission's *Service Rules Order* notes, other types of services, including AWS, may not be covered under the existing copyright-license agreement and may require the Commission to negotiate a supplemental agreement to the licensing agreement it has reached with Rand McNally. *See Service Rules Notice*, 19 FCC Rcd at 24 n.53. With PCS, however, Rand McNally and the Commission have already successfully concluded a wide-ranging copyright license agreement once before. If the Commission licenses H Block as PCS, therefore, the existing copyright license may not require any change, or may only require a minor conforming amendment to adjust to the new band plan.

[100] *Amendment of the Commission's Rules Regarding the 37.0-38.6 GHz and 38.6-40.0 GHz Bands*, Report and Order and Second Notice of Proposed Rulemaking, 12 FCC Rcd 18600, ¶ 14 (1997).

variety of services.[101] Indeed, licensing H Block on a BTA basis will encourage small businesses to provide services in the 1915-1920/1995-2000 MHz band because a small business interested in serving only a single area could bid on the BTA for that area alone and gain affordable access to the desired community. Providing BTA geographic service areas for this new spectrum would also allow large and small incumbent PCS licensees alike to expand and supplement their existing spectrum holdings in a cost-effective manner. The Commission has licensed much of the existing PCS bands to which the 1915-1920/1995-2000 MHz spectrum Block is adjacent on a BTA basis. If the Commission employs BTAs again in this case, incumbent PCS licensees of all sizes will have the opportunity to expand their capacity to deliver services to consumers without having to acquire spectrum in areas where existing resources do not permit prospective bidders to provide service. As a result, incumbent carriers can supplement their spectrum holdings to offer more competitive service in the CMRS market. The increase in competitive pressures in the CMRS market will, in turn, encourage carriers to innovate, reduce costs, and expand service offerings.

BTAs have a proven record of ensuring that millions of consumers receive high-quality, low-cost mobile wireless services. As the Commission recognized in licensing the PCS bands, BTA geographic service areas promote the "rapid deployment and ubiquitous coverage of PCS and variety of services and providers."[102] BTAs promise to deliver the same benefits in the 1915-1920/1995-2000 MHz spectrum that they have elsewhere. Licensing the H Block on a BTA basis will promote the Commission's spectrum-management goals of achieving flexible, efficient spectrum use.

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[101] *Id.* at ¶ 15 ("BTAs offer a sufficiently large service area to allow applicants flexibility in designing a system to maximize population coverage and to take advantage of economies of scale necessary to support a successful operation.")

[102] *See Amendment of the Commission's Rules to Establish New Personal Communications Services,* Second Report and Order, 8 FCC Rcd 7700, ¶ 73 (1993).

Adopting a single, nationwide license for spectrum in the 1915-1920/1995-2000 MHz bands, by comparison, would thwart competition, delay service, and preclude small, minority-owned, and rural businesses from entering the market contrary to the goals of Section 309(j)(4)(c) of the Act. Auctioning a single, nationwide license for the H Block will ensure an extraordinarily small number of bidders participate. Although the CMRS industry contains many fiercely competitive operators, many of even the largest CMRS licensees simply could not meet the anticipated reserve price for a single, nationwide geographic area license. As a rule, auction theory provides that increasing the number of bidders increases the likelihood that the winning bidder will be the one who will truly bring the spectrum to its highest valued use because the expected difference between the participants' highest and next highest valuations on this spectrum will decrease with more participants. While determining the area most likely to result in a higher number of participants is not an exact science and must be counterbalanced against the Commission's other statutory goals, the very limited universe of potential bidders capable of bidding on a single, nationwide license will result in artificially depressed auction prices. The exclusionary nature of a single licensing scheme would also prevent many of the potential bidders that may be more capable of ensuring this spectrum serves the public at its highest valued use from participating in an auction. In this way, creating a single nationwide license will reduce investment in the band, delay useful services, and disserve the public interest.

Naturally, bidding levels that are too high for even some of the largest players in the industry would quickly overwhelm small businesses. Even with the use of bidding credits, small, minority-owned, and rural businesses would have to bid on an area far larger than anything they might remotely wish to serve. Adopting a single nationwide license, therefore, would not only prevent some large, nationwide CMRS carriers from participating in the auction, but also exclude small, minority, and rural businesses from acquiring spectrum in the 1915-

1920/1995-2000 MHz band at auction.

While partitioning and disaggregation might alleviate the problems that a single, nationwide license would cause, carving up the spectrum into more appropriately sized pieces is not a cost-free proposition. On the contrary, the transaction costs of reducing a single nationwide H Block license into 493 BTAs or similarly small license areas more compatible with the existing PCS licensing regime would be substantial. Even if the single, nationwide H Block license holder were willing to negotiate with other licensees, the costs of negotiating hundreds of smaller sub-licensing arrangements in this case may very well cost more than the licensee would gain in revenue from the would-be new H Block entrant. As a result, a single, nationwide license holder of H Block spectrum may simply decide not to partition the spectrum or might do so only at supra-competitive rates. Whether through increased transaction costs or monopoly rents, however, adopting a single, nationwide license imposes large costs on other would-be entrants that would extend inexorably to the general public, which would ultimately have to bear the burden of the artificially increased acquisition costs of spectrum.

To reduce transaction costs, encourage investment, and allow broad participation from businesses large and small, therefore, the Commission should license the 1915-1920/1995-2000 MHz band on a BTA basis.

V. TO MINIMIZE DISPUTES, MAXIMIZE ADMINISTRATIVE EFFICIENCIES, AND ENSURE INCUMBENTS ARE MADE WHOLE, INCUMBENT RELOCATION AND REIMBURSEMENT SHOULD RELY ON A CLEAR, NON-CONTINGENT DIVISION OF RESPONSIBILITIES.

In the *Service Rules Notice*, the Commission noted that incumbent broadcast auxiliary licensees occupy the 1995-2000 MHz band 2020-2025 MHz bands.[103] In addition, the Commission noted that licensing the 1915-1920 MHz band would require new licensees to reimburse the designated band clearing agent, UTAM, Inc. (UTAM), its present and future

[103] *Service Rules Notice*, 19 FCC Rcd at ¶ 50.

expenses in clearing the 1915-1920 MHz band for an alternative use.[104]

Nextel has a unique perspective on the challenges of rolling out service on encumbered spectrum. Nextel's entire operating history has depended upon inter-operating with traditional SMR incumbents and negotiating in the secondary market to clear SMR spectrum for the introduction or growth of Nextel's iDEN operations. Indeed, prior to the Commission's decision to employ wide-area geographic licensing of SMR spectrum in 1990s, *all* of the band-clearing activities that Nextel conducted depended upon negotiating deals to purchase the assets of 800 MHz SMR incumbents. More recently, Nextel may soon elect to relocate all BAS operations from the 1990-2025 MHz band and to reimburse UTAM for a proportionate share of the relocation expenses it has incurred at 1910-1915 MHz band in exchange for replacement spectrum under the terms of the *800 MHz Report and Order*. In light of its relocation activities, Nextel has perhaps the most extensive experience in negotiating relocation of incumbent operators of any Commission licensee today.

If there is any one lesson from Nextel's long history of relocation experiences it is this: the Commission's rules governing relocation and reimbursement should be simple and non-contingent. Introducing too many variables and contingencies into the relocation process will only serve to delay relocation, raise costs, increase the likelihood of disputes, and ultimately disserve the public interest.

A. Permitting BAS Relocation Plans that Relocate Some, But Not All, BAS Licensees Would Create Substantial Market-Coordination and Interference Problems and May Prevent Timely National Relocation of BAS Licensees.

In the *Service Rules Notice*, the Commission noted that use of the 1995-2000 and 2020-2025 MHz bands would require relocating incumbent BAS licensees now operating in the 1990-

[104] *Id.* at ¶ 38 (citation omitted).

2110 MHz band.[105] If Nextel accepts the *800 MHz Order*, Nextel must fund the entire cost of relocating all BAS incumbents nationwide from the 1990-2025 MHz band and complete the BAS relocation process within thirty months of the effective date of the *800 MHz Order*.[106] As an alternative to the *800 MHz Order* relocation process, the Commission's *Service Rules Notice* seeks comment on whether and how it should permit new licensees in the 1995-2000 MHz band to relocate BAS from the 1990-2025 MHz band on an accelerated basis.[107]

Permitting advance relocation of certain BAS markets outside of the master schedule that the broadcast industry is developing in cooperation with Nextel would complicate, disrupt, delay, and increase the cost of BAS relocation as a whole. Under the *800 MHz Order*, Nextel would need to relocate all BAS licensees in the 1990-2025 MHz band and provide them with comparable facilities *within thirty months* after the effective date of the *800 MHz Order*.[108] Among other things, Nextel would need to work with all affected broadcast parties in developing a joint relocation schedule and implementation plan, submit both the schedule and the plan to the Commission for approval, and then implement it. To ensure Nextel can meet these requirements within the aggressive, thirty-month deadline for the BAS transition, Nextel, MSTV, NAB, SBE and other interested broadcast parties have already begun to develop a joint relocation schedule and implementation plan for submission to the Commission.

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[105] *Id.* at ¶ 50.

[106] *800 MHz Order*, 19 FCC Rcd at ¶ 252.

[107] *Service Rules Notice*, 19 FCC Rcd at ¶ 50. The Commission's request for public comment concerning the costs and benefits of other licensees' conducting partial or parallel BAS relocations outside of the national BAS relocation plan that the Commission has already authorized indicates that insufficient information exists at present to justify prior entry into the 1995-2000 MHz band.

[108] *800 MHz Order*, 19 FCC Rcd at ¶ 252.

Though not yet finalized, the implementation plan and schedule represent a careful balancing of industry need against available resources. Broadcasters have long expressed concern that anything less than a fully coordinated, comprehensive plan for BAS relocation would disrupt the live coverage of local emergencies, news, and sports that the public has come to rely upon.[109] Local newscasts, for example, use BAS channels to include reports from electronic newsgathering (ENG) sources from several locations per station and newscasts in a market typically occur at the same time across stations. As the Media Security and Reliability Council has explained, moreover, broadcasters' ENG facilities are vitally important during a national emergency because they ensure "robust and redundant ways [of]…delivering live news and information from a remote site."[110] Given the importance of BAS to the nation, the Commission has ordered the joint implementation plan of Nextel-MSTV-NAB-SBE to specifically address the timing of individual BAS market relocations, adopt measures to minimize disruption to ENG services during the transition, and take other steps to ensure an "expeditious and efficient relocation process."[111]

The joint implementation plan must also account for the interdependent nature of the BAS stations. BAS licensees in a market typically use all seven BAS channels in the 1990-2025 MHz band and local frequency coordinators in a TV market coordinate channel usage on a dynamic basis. The highly contextual, tightly integrated nature of BAS makes isolated, link-by-

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[109] *See, e.g.,* Joint Comments of the Association for Maximum Service Television and the National Association of Broadcasters, IB Docket 00-258 at 11 (filed Oct. 22, 2001) ("the Commission should reallocate all BAS incumbents nationwide *in a single transition*") (emphasis added).

[110] Media Security and Reliability Council, *Comprehensive Best Practices Recommendations,* 7 (Mar. 2, 2004); *accord 800 MHz Order,* 19 FCC Rcd at ¶ 250 ("BAS is a critical part of the broadcasting system by which emergency information and entertainment content is provided to the American public."). During the September 11 attacks, for example, BAS operations made live coverage of the unfolding events possible.

[111] *800 MHz Order,* 19 FCC Rcd at ¶253.

link relocation infeasible; the BAS stations' integration also renders most regional approaches based on traditional CMRS geographic license area boundaries impractical. BAS licensees operate regionally throughout Neilson Designated Market Area (DMAs), which do not correspond to the boundaries of any of the geographic service areas of cellular networks. Moreover, the boundaries of a DMA market area are themselves not necessarily the final word on the proper scope of BAS relocation in that DMA. Stations operating on a DMA border, for example, may technically not require relocation, but may serve parts of the DMA such that they need to be relocated with the DMA. Nextel will sometimes need to relocate more BAS facilities than a raw DMA-based interference analysis might indicate to prevent disruption of the existing ENG capabilities in that DMA.

An additional critical factor that Nextel, MSTV, NAB, SBE, and other interested broadcast parties must consider are the limited resources that physically exist to implement the BAS transition process. First, there are a finite number of qualified engineers, tower climbers, and broadcast technicians in the country. To keep the jointly negotiated implementation plan for the BAS relocation plan on schedule, these skilled workers, who are already in high demand due to the nationwide transition to digital television, will need to work in a specific DMA at a specific time. Conflicting demands for their time and services from *ad hoc* relocations will undercut the national plan that the Commission approved in the *800 MHz Order*. Second, a very limited supply of BAS replacement equipment – radios, controllers, and filters suitable for use at the relocated BAS frequencies – is available on the market at any price. Permitting a new entrant to relocate BAS on an *ad hoc* basis would disrupt the national BAS relocation plan's scheduled deployment of this equipment. Third, some of the group owners represented by the broadcast trade associations that are involved in formulating the national BAS transition plan hold numerous BAS licenses in markets throughout the country. Although these BAS licenses may be located in separate geographic markets, group owners can realize economies in the negotiation and implementation of the BAS transition process by working with one relocating party as opposed to two, three, or hundreds of different relocating parties if alternative BAS relocation plans are permitted. In short, permitting *ad hoc* BAS relocation runs counter to the objectives that the Commission has instructed Nextel and the broadcasters to achieve in developing and implementing the national BAS transition.

For these reasons, granting individual H Block licensees the option of relocating BAS licensees from the 1990-2025 MHz on a schedule different from the one jointly negotiated between Nextel and representatives of the broadcast industry would upend the complex, integrated plan for national BAS transition. The decision-making process among broadcasters and Nextel for a national BAS transition has taken into account BAS use, geographic licensing areas, the integrated nature of the service, human resources, equipment, and many other variables. If the Commission were to permit a new entrant to implement alternative relocation plans for BAS, the new entrant would effectively have the ability to re-categorize affected geographic areas and re-prioritize those geographic areas over the jointly negotiated plan that Nextel and the broadcast industry will have painstakingly settled pursuant to the Commission's directive. The process of revisiting these decisions to accommodate *ad hoc* BAS relocations would much more likely delay the national BAS transition and increase its costs, rather than accelerate it and reduce expenses.

Broadcasters have already devoted substantial time and energy to coalescing around a single, comprehensive plan for the nationwide transition of BAS. Permitting other parties to implement something less than a comprehensive, nationwide relocation of the BAS licensees will disrupt the national BAS relocation plan and divert scarce resources from the mission of ensuring that all BAS licensees are relocated within thirty months of adoption of the *800 MHz Order*.

B. A Per Licensee Approach to Allocating UTAM Expenses Will Divide Expenses Equitably Among Licensees with a Minimum Administrative Oversight While Ensuring UTAM Receives Full and Timely Reimbursement of Its Relocation Expenses.

The Commission designated UTAM to coordinate and manage the transition of the 1910-1930 MHz band from Private Operational-Fixed Microwave Service (OFS) to unlicensed PCS use.[112] H Block licensees will occupy 25 percent of the spectrum formerly assigned to unlicensed PCS. In its *Allocation Order*, therefore, the Commission directed H Block licensees to reimburse UTAM for 25 percent of its total costs in clearing the 1910-1930 MHz band.[113] In its *Service Rules Notice*, the Commission sought comment on how best to apportion responsibility for relocation costs if there were multiple H Block licensees.[114] The Commission proposed that licensees pay a pro-rated amount of the overall amount based on the number licenses a carrier holds.[115]

Nextel supports this proposal. While bidders will never know prior to the auction precisely how much UTAM might ultimately spend in relocating OFS licensees from the 1910-1930 MHz band, reasonably diligent bidders can develop a fairly good estimate of total relocation expenses that UTAM is likely to incur by gathering information about expenses

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[112] *Amendment of the Commission's Rules to Establish New Personal Communications Services*, Fourth Memorandum Opinion and Order, 10 FCC Rcd 7955 (1995); *see also* 47 C.F.R. §§ 24.239-24.53 and 101.69-101.81.

[113] *See Allocation Order*, 19 FCC Rcd at ¶¶ 53-56. Specifically, the Commission concluded that the licensees of the band should reimburse 25% of UTAM's total relocation costs, including its future payment obligations for links already relocated, on a pro-rata shared basis. *Id.* at 53.

[114] *Service Rules Notice*, 19 FCC Rcd at ¶ 41.

[115] *Id.*

incurred for other OFS relocation programs. To further reduce uncertainty, the Commission should adopt its proposal in the *Service Rules Notice* to direct UTAM to provide a good faith estimate of total current and future expenses needed to relocate all OFS licensees from the 1910-1930 MHz band.[116] Under a per license method of assigning expenses, a bidder would divide the total number of licenses they intend to hold by the total number of geographic area licenses the Commission intends to auction and then multiply the resulting fraction by the 25% share of UTAM's total costs attributable to the 1915-1920 MHz band. Each H Block licensee would then pay UTAM its share of OFS relocation expenses based on the number of licenses it holds, subject to "true up" after the auction to account for any unsold licenses.[117] Finally, each H Block licensee that pays its *pro rata* share of UTAM's expenses to cover the expenses assigned to unsold H Block licensees would receive a right to collect their *pro rata* share of the unsold licenses' UTAM expenses when and if the unsold H Block licenses are licensed.

As an example, if UTAM's total estimated expenses for clearing the entire 1910-1930 MHz band were $1,000,000, then under the *Allocation Order* the H Block licensees are responsible for 25% of that total, or $250,000. Assuming Licensee A held 3 out of 493 H Block BTA licenses, Licensee A would be responsible for 3/493 of $250,000, or approximately $1521. If only 488 BTA licenses were sold and five BTA licenses were not sold during the auction, Licensee A would also be responsible for paying UTAM an additional 3/488 proportional share of the total UTAM relocation expenses assigned to the five geographic area licenses that bidders

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[116] *Service Rules Notice*, 19 FCC Rcd at ¶ 43.

[117] This division of expenses can be expressed mathematically as follows:

$$\left(\frac{x}{y}\right)(25\% Estimated.UTAM.Expenses) + \left(\frac{x}{y-z}\right)\left(\left(\frac{z}{y}\right)(25\% Estimated.UTAM.Expenses)\right) = Licensee's.UTAM.Payment$$

where "x" represents the number of licenses held by an H Block licensee, "y" represents the total number of licenses available at the auction, and "z" represents the total number of unsold geographic area licenses available in the auction.

did not purchase at auction, or slightly more than $15.[118] If the Commission subsequently licensed the previously unsold H Block geographic area licenses, Licensee A would then have a claim to recoup its $15 proportional share of the "trued up" UTAM expenses from the late-arriving H Block licensees.

The Commission is right to recognize that a fundamental challenge to any successful auction is predicting the prices of all of the relevant goods before they are known. As in any common value auction, a winner's curse that results in the winning party paying too much for a given license is always possible. In this case, however, the Commission can minimize uncertainty by adopting a simple per license division of UTAM's total expenses for OFS relocation and directing UTAM to offer a good faith estimate of total likely expenses to clear the band. A per license approach under these circumstances will allow potential bidders to estimate their total liability to UTAM with enough certainty to reasonably estimate the total value of the spectrum rights they would acquire at auction.

The only remaining question is whether to clarify precisely when H Block licensees would need to pay their pro rata share of UTAM expenses. The Commission directed that H Block licensees pay these expenses "prior to the commencement of operations."[119] The Commission often uses the term "commencement of operations" to refer to the time when the licensee begins offering commercial service to the public. The Commission should use that definition in this case because many of the licensees that will operate in this band are likely to use revenue generated from the offering of commercial service to the public to pay their shares of the expenses UTAM incurred to relocated fixed services from the 1910-1930 MHz band. By

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[118] Licensee A's share of additional expenses to account for unsold licenses is calculated using the relevant portion of the formula in footnote above. Using the numbers in this example, Licensee A's precise share of additional expenses is: (3/488) (5/493) ($250,000) =$15.59.

[119] *Service Rules Notice*, 19 FCC Rcd at ¶ 42.

defining commencement as the date on which commercial offering of service begins rather than some other date, the Commission will ensure UTAM receives full payment without unduly burdening carriers with another pre-operation expenditure prior to the time they can offer service to the public.

VI. H BLOCK LICENSEES SHOULD POSSES THE SAME RIGHTS AND RESPONSIBILITIES AS OTHER COMMISSION LICENSEES.

The Commission sought comment on whether it should apply traditional commercial wireless rules to the 1915-1920 MHz, 1995-2000 MHz, 2020-2025 MHz and 2175-2180 MHz bands. These rules address matters ranging from general rules on RF safety, to substantial service requirements, to international coordination obligations, to the standard license terms.[120] Except where otherwise noted below, Nextel agrees that the generally applicable commercial wireless rules should apply to these bands. The H Block, in other words, should receive the same rights and responsibilities as any other commercial wireless licensee.

A. While *Ex Ante* Spectrum Aggregation Limits Are Not Required, Continued Enforcement of Carrier-Specific Limitations on Market Power Remains Essential.

The Commission tentatively concluded that it did not need to impose a spectrum aggregation limit or eligibility restrictions for the H and J Blocks of spectrum because open eligibility in these bands would not pose a significant likelihood of substantial harm to competition in any specific markets.[121] Nextel agrees with the Commission's tentative

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[120] *Service Rules Notice*, 19 FCC Rcd at ¶ 116. To the extent the *Service Rules Notice* recommends adopting specific Part 27 rules, Nextel recommends substituting the analogous Part 24 rule in their place. *See* discussion *supra* § II. For example, the Commission proposed that section 27.12 should apply to applicants applying for licenses in the 1915-1920, 1995-2000, 2020-2025 and 2175-2180 MHz bands. Section 27.12 imposes foreign ownership and citizenship requirements that restrict the issuance of licenses to certain applicants. With respect to the 1915-1920, 1995-2000 MHz bands, Nextel recommends that the Commission apply the analogous Part 24 rule. *See* 47 C.F.R. § 24.12.

[121] *Service Rules Notice*, 19 FCC Rcd at ¶ 67.

conclusion that a generalized restraint on carriers' ability to acquire spectrum in these bands is not warranted; however, the addition of the H and J Blocks to the pool of available spectrum does not diminish the need to continue enforcement of carrier-specific remedies that the Commission has imposed in certain markets. The Commission, for example, specifically forbade Cingular and AT&T Wireless from holding more than 80 megahertz of spectrum in selected markets to limit the combined carriers' aggregation of market power.[122] Nothing in this proceeding should affect the Commission's conclusions about the need for divestment in specific geographic markets to prevent excessive concentration of limited resources in the mobile telephony sector. Thus, to the extent wireless carriers remain subject to divestment or other market-power limitations in other PCS spectrum, those prohibitions should continue at least until the Commission concludes a further carrier-specific review of prevailing market conditions in a given market. While carriers will most likely use the new 10 MHz of spectrum in the 1915-1920/1995-2000 MHz band to compete directly with incumbent PCS licensees on price, services, or innovative technology, any existing carrier-specific limitation will require carrier-specific review based upon a complete record of the circumstances in each geographic market.

B. The Commission Should Adopt Competitive Bidding Procedures That Allow Small and Minority-Owned Businesses an Opportunity to Compete.

The Commission proposed to resolve mutually exclusive applications through competitive bidding.[123] Nextel supports this proposal and the accompanying recommendation that any auction of initial licenses in the 1915-1920 MHz, 1995-2000 MHz, 2020-2025 MHz and 2175-2180 MHz bands remain consistent with the competitive bidding rules set forth in Part 1, Subpart

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[122] *See, e.g., Applications of AT&T Wireless Services, Inc. and Cingular Wireless Corp.*, Memorandum Opinion and Order, WT Docket No. 04-70, FCC 04-255, __ FCC Rcd __ (rel. Oct. 26, 2004) (finding that Cingular's acquisition of AT&T Wireless would cause competitive harm in twenty-two local areas and imposing market-specific remedies, including divestment, to ameliorate the expected harm).

[123] *Service Rules Notice*, 19 FCC Rcd at ¶ 117.

Q, of the Commission's rules, and substantially consistent with the competitive bidding procedures that have been employed in previous auctions.[124] Authorizing competitive bidding to resolve mutual exclusivity in this case would achieve allocative, distributive, administrative, and other efficiencies.

Nextel also supports adopting "designated entity" provisions in this auction with the same small business size standards and associated bidding credits as other recent PCS service rules orders have adopted.[125] Thus, a "small business" should be defined as an entity with average annual gross revenues for the preceding three years not exceeding $40 million, and a very small business should be defined as an entity with average annual gross revenues for the preceding three years not exceeding $15 million. Small businesses should receive a bidding credit of 15 percent and very small businesses should receive a bidding credit of 25 percent. The Commission's use of bidding credits will allow designated entities to compete in the market for commercial wireless services.

The Commission, however, should not adopt a nationwide market for the 1915-1920/1995-2000 MHz band. Nextel agrees with the Commission that a nationwide licensing scheme would raise the cost of implementing service so high that it would preclude small businesses from entering the market even if bidding credits were adopted.[126] H Block is the last piece of spectrum contiguous to the core PCS bands and, as a result, the last logical band in which small and minority-owned businesses might acquire spectrum on the primary market to provide or expand their commercial wireless services offerings in competition with incumbent carriers. The likely *exclusion* of small and minority-owned businesses from the bidding for H

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[124] *Id.* at ¶ 118.

[125] *Id.* at ¶ 123.

[126] *Id.* at ¶ 124.

Block should be reason enough alone for the Commission to reject creating a single nationwide license in the 1915-1920/1995-2000 MHz band.[127]

VII. CONCLUSION

Every PCS carrier in the market has expressed a desire to obtain additional PCS spectrum to better serve its customers. Recognizing the imperative need for additional spectrum suitable for PCS, the Commission allocated the 1915-1920 MHz, 1995-2000 MHz, 2020-2025 MHz and 2175-2180 MHz bands for commercial wireless services' use. The Commission can help carriers satisfy the growing demand for PCS services from the public by adopting H Block service rules that balance the need for flexible service rules against the necessity of protecting incumbent PCS licensees against interference. With respect to the H Block of spectrum, the best way to balance these competing demands is to ensure that the same rights and responsibilities that apply to PCS licensees apply to future H Block licensees. To maximize economies of scale and minimize inefficiency stemming from duplicative rules or overlapping license areas, H Block licensees should receive the same geographic licensing area, operate under the same technical limits, benefit from the same high standard of industry cooperation, and generally observe the same commercial wireless service rules that other carriers do today. Adopting

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[127] *See* discussion *supra* § IV (advocating BTA-sized geographic licensees to promote competition, minimize transaction costs, and encourage competitive entry of small businesses).

similar rules for similarly situated licensees will enhance competition, accelerate investment, ensure diverse license holdings, and serve the public interest.

Respectfully submitted,

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Appendix A:

CDMA Development Group System Performance Tests

CDG

System Performance Tests

(Optional)

Revision 3.0

CDG 35

April 9, 2003

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REVISIONS

Revision Level	Revision Date	Remarks
0.0	March 3, 1997	Original Straw Man
1.0	April 14,1998	Initial Release to CDG Added ERP to acronyms list Updated Section 1, Test Equipment Setup New Figure s 1.1.2-1 and 1.1.2-2 Deleted Section 3 content, made reserved
1.1	June 10, 1998	Test 1.2, maximum acoustic time delay changed from 100 ms to 140 ms. Reworded test 1.4.2 step e. Deleted 5th column from table A.3.3-1 and replaced associated notes with 1 note. Added dBm0 to list of terms/definitions. Added note to tests 1.2 and 1.4 definition. Added tests 4.3, 4.4 and 4.5
1.2	July 10,1998	Retitled document CDG 35 to: Optional System Performance Tests. Revised title, updated definition, and added note to test 1.4, System Frequency Response.
2.0	August 1, 1998	Release to CDG under new title.
2.1	December 2, 1998	Renamed 40% voice activity file called out in test 2.1, and revised associated note.
2.2	May 4, 1999	Added DCR and DMOS to Acronyms List. Revised dBm0 definition in Supplementary Terms and Definitions. Revised Introduction. Revised Test Methodology. Revised Objective Techniques. Revised Test 1.3. Revised Test 1.4 Definition. Revised Appendix A. Changed Appendix B title.
2.3	June 20, 2000	Added new section 3, Data Services
3.0	April 9, 2003	No changes from 2.3

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FOREWORD

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Purpose

The purpose of this document is to provide the CDMA community with a collection of standardized tests to objectively evaluate the performance of CDMA from an end user perspective. These tests generally do not have pass/fail criteria. In some cases however, a minimum standard is recommended. These tests bench mark performance of the system, and help identify sources of impairments, if any.

Acronyms and Abbreviations

Acronyms and abbreviations presented in this document, are defined as follows:

Acronym or Abbreviation	Description
AC	Authentication Center
ACCM	Asynchronous Control Character Map
ACR	Absolute Category Rating
AMPS	Advanced Mobile Phone Service (analog)
AT	Attention (condition in modem control)
AWGN	Additive White Gaussian Noise
BS	Base Station
CDG	Code Division Multiple Access (CDMA) Development Group
CDMA	Code Division Multiple Access
Chip	Smallest Portion of a Frame
CMT	Cellular Messaging Teleservice
CPN	Calling Party Number
CPT	Cellular Paging Teleservice
CRC	Cyclic Redundancy Check
CSC	Customer Service Center
DCE	Data Communication Equipment
DCMS	Display Capable Mobile Station
DCR	Degradation Category Rating
DMOS	Degradation Mean Opinion Score
DTMF	Dual Tone Multiple Frequency
EM	Escape Mode
ERP	Effective Radiated Power
ESN	Electronic Serial Number
FCS	Frame Check Sequence

Acronym or Abbreviation	Description
FER	Frame Error Rate
ICMP	Internet Control Message Protocol
IMSI	International Mobile Station Identity
IP	Internet Protocol
ITU	International Telecommunication Union
IWF	Inter-working Function
Km/h	Kilometers Per Hour
LAP-M	Link Access Protocol-M
LCP	Link Control Protocol
MC	Message Center
MCC	Mobile Country Code
MER	Message Error Rate
MIN	Mobile Station Identification Number
MMR	Modified Modified Read (compression method)
MNP	Microcom Network Protocol
MOS	Mean Opinion Score
MS-BSS	Mobile Station - Base Station Standard
MSC	Mobile Switching Center
MSS	Maximum Segment Size
MT	Mobile Terminal
NAK	Negative Acknowledge - Handshake protocol by which an incorrect or incomplete sequence transmission is repeated.
NAM	Number Assignment Module
NID	Network Identifier
OA&M	Operation, Administration and Maintenance
OCNS	Orthogonal Channel Noise Simulator
OTAF	Over the air function
OTASP	Over the air service provisioning
OUNS	Other User Noise Simulator
PCS	Personal Communications Service
PCSC	Personal Communications Switching Center
PIN	Personal Identification Number
PLC	Private Long Code
POTS	Plain Old Telephone Service

Acronym or Abbreviation	**Description**
PPP	Point-to-point protocol
PSAP	Public Service Answering Point
PSTN	Public Telephone Switching Network
RLP	Radio Link Protocol
SAC	Subscriber Access Control
SCM	Station Class Mark
SID	System Identification Number
SMS	Short Message Service
SR	Service Redirection
SSD	Shared Secret Data
TCH	Traffic Channel
TCP	Transmission Control Protocol
TDMA	Time Division Multiple Access
TE	Terminal Equipment
$TE2_L$	Terminal Equipment at land connection point
$TE2_M$	Terminal Equipment at mobile connection point
TMSI	Temporary Mobile Station Identity
TSB	Technical Service Bulletin
V.42	CCITT recommended error correction protocol
V.42-bis	CCITT recommendation for compression method
VJ	Van Jacobson (compression protocol)
VMN	Voice Mail Notification

Supplementary Terms and Definitions

AWGN Source - Additive White Gaussian Noise generator.

Bad Frames - Frames classified as erasures or 9600 bps frames, primary traffic only with bit errors.

dBc - Ratio (in dB) of the sideband power of a signal, measured in a given bandwidth at a given frequency offset from the center frequency of the same signal, to the total inband power of the signal. For CDMA, the total inband power of the signal is measured in a 1.23 MHz bandwidth around the center frequency of the CDMA signal.

dBm0 - Power in dbm measured at, or referred to a point of zero relative transmission level. In a reference G.711 system, a maximum-level 1-kHz tone, whose peaks just reach the digital levels of the PCM codec, has a level of +3.14 dBm0.

E_b - Average energy per information bit for the Sync Channel, Paging Channel, or Forward Traffic Channel at the mobile station antenna connector.

E_bN_0 - Energy-per-bit-to noise-per-hertz ratio.

ESN - Electronic Serial Number.

- Ratio of the combined received energy per bit to the effective noise power spectral density for the Sync Channel, Paging Channel, or Forward Traffic Channel at the mobile station antenna connector.

E_c - Average energy per PN chip for the Pilot Channel, Sync Channel, Paging Channel, Forward Traffic Channel, power control sub channel, or OCNS.

- Ratio of the average transmit energy per PN chip for the Pilot Channel, Sync Channel, Paging Channel, Forward Traffic Channel, power control sub channel, or OCNS to the total transmit power spectral density.

FER - Frame Error Rate of Forward Traffic Channel. The value of FER may be estimated by using Service Option 2.

Good Frames - Frames not classified as bad frames. See also Bad Frames.

Good Message - A message received with a correct CRC.

I_o - Total received power spectral density, including signal and interference, as measured at the mobile station antenna connector.

I_{oc}- Power spectral density of a band-limited white noise source (simulating interference from other cells) as measured at the mobile station antenna connector.

I_{or} - Total transmit power spectral density of the Forward CDMA Channel at the base station antenna connector.

$_{or}$ - Received power spectral density of the Forward CDMA Channel as measured at the mobile station antenna connector.

N_t - Effective noise power spectral density at the mobile station antenna connector.

OCNS E_c - Average energy per PN chip for the OCNS.

- Ratio of the average transmit energy per PN chip for the OCNS to the total transmit power spectral density.

Paging_Chip_Bit - Number of PN chips per Paging Channel bit, equal to 128 ? v where v equals 1 when the data rate is 9600 bps and v equals 2 when the data rate is 4800 bps.

Paging E_c - Average energy per PN chip for the Paging Channel.

- Ratio of the average transmit energy per PN chip for the Paging Channel to the total transmit power spectral density.

Personal Station - Used interchangeably with Mobile Station.

Piece-wise Linear FER Curve - An FER-versus-E_b/N_t curve in which the FER vertical axis is in log scale and the E_b/N_t horizontal axis is in linear scale expressed in dB, obtained by interpolating adjacent test data samples with straight lines.

Piece-wise Linear MER Curve - An MER-versus-E_b/N_t curve in which the MER vertical axis is in log scale and the E_b/N_t horizontal axis is in linear scale expressed in dB, obtained by interpolating adjacent test data samples with straight lines.

Pilot E_c - Average energy per PN chip for the Pilot Channel.

Pilot - Ratio of the combined pilot energy per chip to the total received power spectral density at the mobile station antenna connector.

- Ratio of the average transmit energy per PN chip for the Pilot Channel to the total transmit power spectral density.

Pilot Channel - Unmodulated, direct-sequence spread spectrum signal transmitted continuously by each CDMA base station. The Pilot Channel allows a mobile station to acquire the timing of the Forward CDMA Channel, provides a phase reference for coherent demodulation, and provides a means for signal strength, comparisons between base stations for determining when to hand off.

Pilot PN Sequence - Pair of modified maximal length PN sequences with period 2^{15} used to spread the Forward CDMA Channel and the Reverse CDMA Channel. Different base stations are identified by different pilot PN sequence offsets.

Power Control Bit - Bit sent in every 1.25 ms interval on the Forward Traffic Channel to signal the mobile station to increase or decrease its transmit power.

Power Control E_c - Average energy per PN chip for the power control subchannel.

Service Option 2 - Mobile station data loopback test mode for Multiplex Option 1 as specified in TIA/EIA/IS-126-A.

Service Option 9 - Mobile station data loopback test mode for Multiplex Option 2 as specified in TIA/EIA/IS-126-A.

Slotted Mode - Operation mode of the mobile station in which the mobile station monitors only selected slots on the Paging Channel when in the Mobile Station Idle State.

Sync Channel - Code channel 32 in the Forward CDMA Channel which transports the synchronization message to the mobile station.

Sync_Chip_Bit - Number of PN chips per Sync Channel bit, equal to 1024.

Sync E_c - Average energy per PN chip for the Sync Channel.

- Ratio of the average transmit energy per PN chip for the Sync Channel to the total transmit power spectral density.

Traffic_Chip_Bit - Number of PN chips per Traffic Channel bit, equal to 128 ? v for Rate Set 1 and 85.33... ? v for Rate Set 2. When the data rate is 14400 bps or 9600 bps, v equals 1; when the data rate is 7200 bps or 4800 bps, v equals 2; when the data rate is 3600 bps or 2400 bps, v equals 4; and when the data rate is 1800 bps or 1200 bps, v equals 8.

Traffic E_c - Average energy per PN chip for the Forward Traffic Channel. For the case when the power control subchannel is assumed to be transmitted at the same power level used for the 9600 bps or 14400 bps data rate, the following equations apply:

For Rate Set 1, it is equal to ? (total Forward Traffic Channel energy per PN chip). where v equals 1 for 9600 bps, v equals 2 for 4800 bps, v equals 4 for 2400 bps, and v equals 8 for 1200 bps traffic data rate. For Rate Set 2, it is equal to ? (total Forward Traffic Channel energy per PN chip). where v equals 1 for

14400 bps, v equals 2 for 7200 bps, v equals 4 for 3600 bps, and v equals 8 for 1800 bps traffic data rate. The total Forward Traffic Channel is comprised of traffic data and a power control subchannel.

- Ratio of the average transmit energy per PN chip for the Forward Traffic Channel to the total transmit power spectral density.

Valid Power Control Bit - A valid power control bit is sent on the Forward Traffic Channel in the second power control group following the corresponding Reverse Traffic Channel power control group which was not gated off and in which the signal strength was estimated.

Tolerances

CDMA System Parameter Tolerances

CDMA parameters are specified in IS-95-A and J-STD-008. All parameters indicated are exact unless an explicit tolerance is stated.

Measurement Tolerances

Unless otherwise specified, a measurement tolerance, including the tolerance of the measurement equipment, of ±10% is assumed.

Unless otherwise specified, the ${}_{or}/I_{oc}$ value shall be within ±0.1 dB of the value specified, and the I_{oc} value shall be within ±5 dB of the value specified.

Document Reference

An Objective Measure for Predicting Subjective Quality of Speech Coders, by S. Wang at al., IEEE Journal on Selected Areas in Communications, Vol. 10, No. 5, June 1992

ANSI/IEEE 820-1984

ANSI J-STD-008-1995, *Personal Station-Base Station Compatibility Requirements for 1.8 to 2.0 GHz Code Division Multiple Access (CDMA) Personal Communications Systems*, 1995.

ANSI J-STD-018-199X (TIA/PN-3385), *Recommended Minimum Performance Requirements for 1.8 to 2.0 GHz Code Division Multiple Access (CDMA) Personal Stations*, 1995.

ANSI J-STD-019-199X (TIA/PN-3383), *Recommended Minimum Performance Requirements for Base Stations Supporting 1.8 to 2.0 GHz Code Division Multiple Access (CDMA) Personal Stations*, 1995.

CDG 36 *Markov Mode Document*

ITU Draft Recommendation P.861 "Objective Quality Measurement of Telephone-band (300 - 3400 Hz) Speech Codecs, February 1996

Measuring the Quality of Speech and Music Codecs, an Integrated Psychoacoustics Approach, by John Beerands of Royal PTT Netherlands

TIA/EIA/IS-52: *Uniform Dialing Procedures and Call Processing Treatment for Cellular Radio Telecommunications* (PN-3166) .

TIA/EIA/IS-53-A *Cellular Features Description*

TIA/EIA/TSB-74 (PN-3570), *Telecommunications Systems Bulletin: Support for 14.4 kbps Data Rate and PCS Interaction for Wideband Spread Spectrum Cellular Systems*, 1995.

TIA/EIA/IS-95-A, *Mobile Station-Base Station Compatibility Standard for Dual-Mode Wideband Spread Spectrum Cellular System*, 1994.

TIA/EIA/IS-97: *Recommended Minimum Performance Standards for Base Stations Supporting Dual-Mode Wideband Spread Spectrum Cellular Mobile Stations*, 1994.

TIA/EIA/IS-98: *Recommended Minimum Performance Standards for Dual-Mode Wideband Spread Spectrum Cellular Mobile Stations*, 1993.

TIA/EIA/IS-99: *Data Services Option Standard for Wideband Spread Spectrum Digital CellularSystem*

TIA/EIA/IS-126-A: *Mobile Station Loopback Service Options Standard*, 1995.

TIA/EIA/IS-637: *Short Message Services for Wideband Spread Spectrum Cellular Systems, 1995*

TIA/EIA/IS-683: *Over-the-Air Service Provisioning of Mobile Stations in Wideband Spread Spectrum Systems* (PN-3569)

1 AUDIO QUALITY TESTS

Introduction

Routine monitoring of CDMA voice quality performance in relation to an established voice quality performance baseline may be an important objective of a network operator in the implementation of new hardware into an existing CDMA network. Having a scored database available for comparison may be an important optional test objective.

Test Methodology

Subjective Techniques

Subjective Mean Opinion Scoring (MOS) and Degradation Mean Opinion Scoring (DMOS) are the ultimate way of measuring audio quality due to the nature of speech. The most common processing used in (D)MOS-predictive methods involves the measurement of distance between the source and processed input samples. In such a case, it is most appropriate to correlate the objective measurement values to the analogous subjective DMOS values (which are referenced to the source material). Only a pure MOS-predictive method, involving no reference input, should be correlated to subjective MOS values (which are derived from an open-loop assessment). The results from the forced correlation of a referenced objective methodology to subjective MOS values should be used with extreme caution (if at all) in the reporting of system quality. This section contains procedures for implementing and administering the baseline subjective (D)MOS tests. These procedures are the same whether the ultimate correlation is to subjective MOS or to subjective DMOS values.

Objective Techniques

Research results suggest the possibility of developing test techniques that correlate well with subjective (D)MOS. Further research may improve upon these techniques or develop new ones. The tests described in this section are not meant to favor one technique over another, except with respect to how successful the technique is in predicting the subjective (D)MOS result under various conditions. This section contains a method for comprehensive evaluation of (D)MOS-predictive methods, by demonstrating the degree of correlation with subjective (D)MOS. Any technique contemplated for the purpose of predicting (D)MOS, within the CDMA system, should be evaluated as prescribed in this section.

Objective measures of audio quality using (D)MOS predictive methods defined in this section should be used within the intent of their design, and with caution. They are not meant to supplant subjective (D)MOS, testing, but to supplement it so that tests can be performed quickly and with less expense. It is not clear yet how well they would work in a wide variety of cases and distortions that occur in the field. This is an area requiring further research by the CDMA community.

Tests should be repeatable and readily implementable in the field, with result turn-around time almost instantaneous. This would be of real appeal to service providers dealing with compressed launch schedules and major system changes such as antenna system changes, introduction of a new service option or rate set, addition of RF carriers, and changes in interference environment.

A majority of (D)MOS-predictive techniques have been developed with the purpose to aid in speech coder optimization and evaluation. The degree of applicability of existing coder tests to overall network quality is at issue. The applicability is there, since speech codec is the most critical part of speech service. However, wireless network quality in general, and audio quality in particular, is a complex issue.

Each of the tests in this section evaluate network quality with respect to one aspect or another. Only taken as a whole can these test provide a comprehensive picture of the network at audio level.

Test Duration

Test time may vary in accordance with the objective and scope of the particular test as determined by the system operator. The test times given in the procedures represent the minimum time necessary to obtain a statistically valid sample for the minimum standard limit stated in the test.

Test confidence intervals are defined in IS-98. Although they apply for lab conditions, in the field the environment is not as predictable and it is governed by a multitude of factors. The confidence intervals in the field are therefore generally more extensive. Whenever possible, the intended confidence level is specified for each test.

Test Equipment Setup

Link Direction and Coupling

Unless otherwise noted, testing should be conducted for both the forward link and the reverse link.

For some tests, either acoustic or electrical (analog audio-circuit) coupling can be used. In general, it is preferred to use acoustic coupling at the mobile station, since that truly represents an end-to-end test. The test engineer may choose acoustic and/or electrical coupling depending on the exact nature and purpose of the test.

At the base station, electrical coupling is preferred because it eliminates effects of the PSTN and landline phone. At times acoustic coupling may be preferred. For example, a field test for echo path loss measured at the mobile station can measure and assess the proper circuit termination within the PSTN circuitry. This may be of interest to the wireless network operator as extensive echo may be negatively perceived by the mobile station user and judged as poor service quality.

To facilitate the separation of mobile station evaluation from base station problems, it is recommended that the following tests be performed with multiple types of handsets.

Test Equipment Capability

For tests requiring audio measurements, mobile station capability to access and record data using an audio breakout box is assumed in the minimum standard. At the base station, this constraint should not exist. Base stations should have the capability to provide the information required as part of routine monitoring of network performance.

For several tests, loopback service options are used where Markov mode may be better suited, since Markov can fully separate the forward from the reverse link. Since Markov mode is not yet standardized by the TIA, loopback service options will remain in place as the standard method of testing. In certain instances testing may be substituted or supplemented by equivalent tests using Markov mode. The Markov document number is CDG RF 36.

1.1 Acoustic Dropouts in Hard Handoffs

1.1.1 Definition

This test will measure audio loss, noise and distortion generated during various types of hard handoffs for both forward and reverse links.

Traceability

CDMA 800: IS-95-A; 6.6.6.2.8, 6.6.6.2.9,

CDMA 1900: J-STD-008; 2.6.6.2.8,

1.1.2 Method of Measurement

a. Set up test equipment for the forward link as shown in Figure 1.1.2-1.

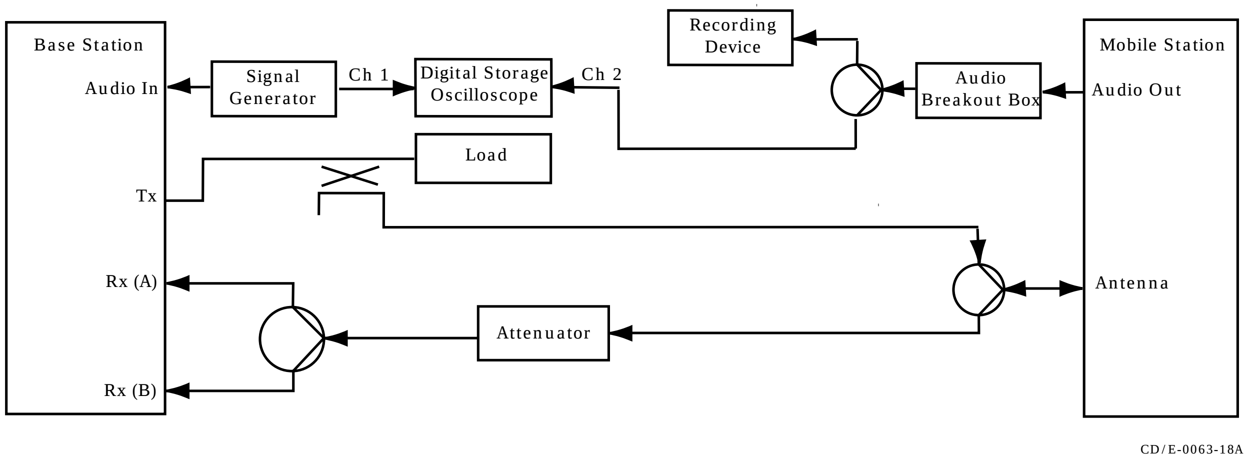


Figure 1.1.2-1 Setup for Testing Acoustic Dropouts in Hard Handoffs for Forward Link

b. Initiate a voice call.

c. Measure system noise with the audio waveform generator output off.

d. Inject a continuous test signal at a level sufficient to ensure the vocoder will pass the signal.

e. Start recording audio at the forward or reverse end of the link.

f. Execute a hard handoff.

g. Stop recording and store the record.

h. Examine the recorded data and determine the duration of any audio dropout. Subjectively evaluate audio quality and make note of any unusual audio effects.

i. Compare noise level during audio dropouts with noise level measured in step c.

j. Set up test equipment for the reverse link as shown in Figure 1.1.2-2, and repeat steps b through i, recording audio on the reverse link.

k. Repeat steps a through j for all available voice service options supported by both the base station and the mobile station.

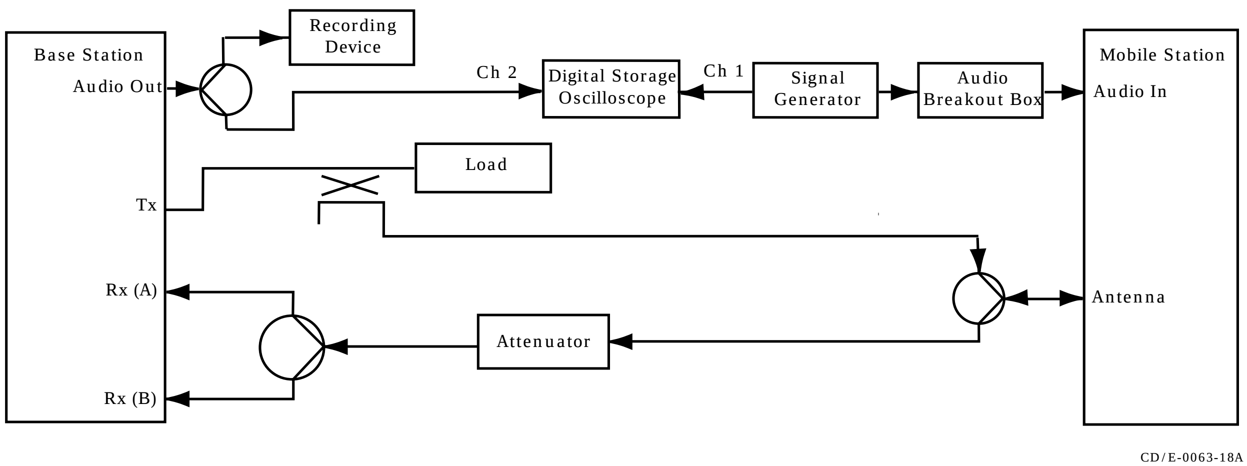


Figure 1.1.2-2 Setup for Testing Acoustic Dropouts in Hard Handoffs for Reverse Link

1.1.3 Minimum Standard

Duration of audio dropouts shall not exceed maximum values and should not exceed typical values specified in Table 1.1.3-1.

Table 1.1.3-1 Limits of Audio Dropouts During Hard Handoff

Handoff Type	Maximum Duration (ms)	Typical Duration (ms)
CDMA to Analog	200	
CDMA-CDMA, different frequency, same BS	440	260
CDMA-CDMA, different frequency, different BS	460	320
CDMA-CDMA, same frequency	400	280

1.2 Acoustic Time Delay

1.2.1 Definition

Acoustic time delay is the time delay from when a signal is introduced in the source acoustic transmit path to when it is acoustically reproduced at the destination. This delay is measured by coupling a single pulse tone in to the transmitter then coupling the output from the receiver. The delay between the two coupled points is then quantified.

Note: This test does not take into account acoustic properties of the handset ear-piece or microphone.

1.2.2 Method of Measurement

a. Configure the test equipment and mobile station under test as shown in figure 1.2.2-1. Either electric or acoustic coupling may be used at the mobile station.

b. Configure the digital storage oscilloscope to trigger on the transmit pulse.

c. Place a rate set 1 call and verify voice path.

d. Inject the tone and measure delay on the digital storage oscilloscope.

e. Repeat steps b through d five times and compute the average delay.

f. Rearrange the setup to make the mobile station the receive side, and repeat steps b through e.

g. Repeat for rate set 2.

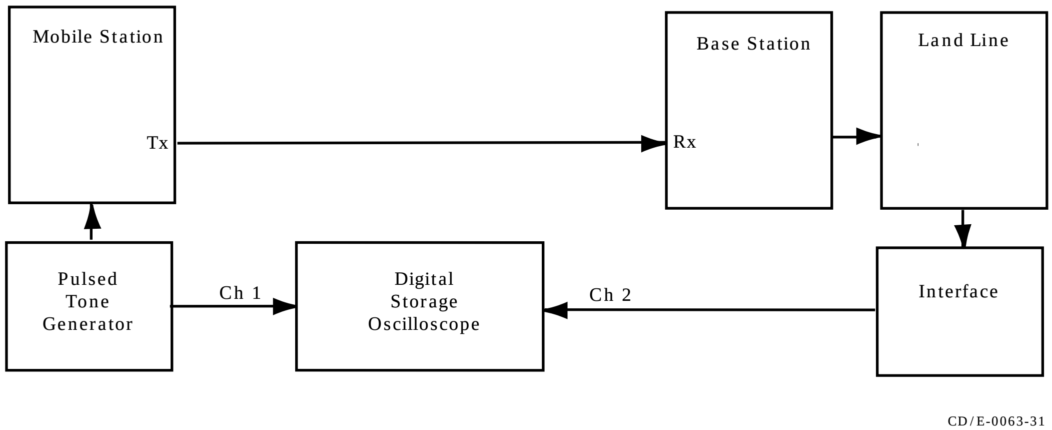


Figure 1.2.2-1 Functional Setup for Testing Acoustic Time Delay

1.2.3 Minimum Standard

Time delay shall be measured from transmit to receive and recorded. Compare the results to a 140 ms target delay. The maximum delay should not exceed 140 ms.

1.3 (D) MOS Predictive Test

1.3.1 Definition

This test represents an automated real time process based on an algorithm which accurately reflects how listeners perceive CDMA voice quality. If comparative bench marking is desired, Voice quality with respect to the reference subjective (D)MOS baseline may be performed.

Depending on the (D)MOS-predictive algorithm the process is either un-referenced (MOS) or referenced (DMOS), the objective measurement process is correlated to either a subjective test based on an Absolute Category Rating (ACR), where listeners associate a quality adjective with the speech to which they are listening, or to a subjective test based on a Degradative Category Rating (DCR), where listeners associate a quality degradation adjective with the referenced speech to which they are listening. These subjective ratings are transferred to a numerical scale, and the arithmetic mean is the resulting (D)MOS number.

The (D)MOS Predictive test is an automated real time two-way method of anticipating either the subjective speech quality or the level of subjective speech quality degradation of the system in either descriptive terms or equivalent numerical ratings as shown in Table 1.3.1-1.

The objective of the (D)MOS Predictive test is to rate speech quality of CDMA calls, automatically and in real time, under various input audio conditions and RF-related impairments.

Table 1.3.1-1 Descriptions in the (Degradation) Mean Opinion Score[1]

Rating	Speech Quality (MOS)	Speech Quality (DMOS)
5	Excellent	Imperceptible
4	Good	Just perceptible but not annoying
3	Fair	Perceptible and slightly annoying
2	Poor	Annoying but not objectionable
1	Unsatisfactory	Very annoying and objectionable

1.3.2 Method of Measurement

a. Select or record a number of sets of flat-weighted test-sentence-pairs approximately 2 minutes in overall length. Refer to Appendix B for example test sentences. With the exception of the speech-to-noise sources, a good generic reference for sentence-pair source material is *"Speech Database Generation for the TDMA-6 Codec Evaluation"*, by Ray Perkins and Brian Sheldon of BNR, presented as TR45.3.5/94.03.08.06. The following is suggested as the scope of the source sentence-pairs.

   Select a total of 8 test speakers with the following characteristics:

   - 4 male subjects, native English speakers
   - 4 female subjects, native English speakers

   For each source set, select two unique sentence-pairs for each talker. A total of six source sets will be required, for a total of 96 talker/sentence-pairs to be used in the subjective tests.

   The sentence-pairs will be level-normalized to -20 dBm0, and the speech-to-noise sources will be created using the procedures presented in ITU-T G.191, *"Software Tools for Speech and Audio Coding Standardization"*, and *"The Software Tool Library"*, by Simao Ferraz De Campos Neto, International Journal of Speech Technology, to be published 1999.

b. Load the source sentence-pair sets from step a into MOS Predictive test vehicle and (D)MOS Predictive test equipment at the Mobile Switching Center (MSC). It is recommended that (D)MOS Predictive test equipment be connected to the cellular network at the MSC rather than elsewhere, to remove any possibility that PSTN landline impairments will impact (D)MOS Predictive results. (D)MOS Predictive mobile equipment shall be electrically coupled to remove unwanted ambient noise. For this test it is assumed that audio levels are set within the (D)MOS Predictive equipment automatically.

c. Choose an appropriate drive route to encompass the range of system performance to be monitored. (Refer to the CDG Stage 3 Interoperability Tests, Foreword, Execution Strategy for typical drive route information)

d. On the mobile side, prepare (D)MOS Predictive test equipment to begin calling (D)MOS Predictive equipment installed at the MSC.

e. On the landline side, prepare (D)MOS Predictive test equipment to begin calling (D)MOS Predictive equipment installed at the mobile station.

f. Establish a call from a CDMA mobile station. As soon as a connection is established, begin scoring call quality and recording the results. Score each sentence-pair as well as produce an overall score for each two minute call source set segment.

[1] IEEE Paper, "An Objective Measure for Predicting Subjective Quality of Speech Coders," Wang, Sekey and Gersho, June 1992.

g. Establish a landline call to a CDMA mobile. As soon as connection is established, commence scoring the call by means of (D)MOS Predictive equipment, producing an overall score for each two minute call source set segment, as well as a (D)MOS-predictive score approximately every 7.5 seconds.

h. In steps i and h, alternate call origination between mobile and landline for duration of test.

i. Label and save all test data at the conclusion of test, which should be maintained for archival purposes.

1.3.2.2 Minimum Standard

a. Gather all the ratings under the categories of reverse link and forward link.

b. Separate (D)MOS scores shall be calculated for the forward and the reverse link. The average (D)MOS Predictive score in the forward or reverse direction shall be in accordance with carrier specification.

1.4 System Frequency Response Test

1.4.1 Definition

Among factors affecting CDMA system voice quality, not directly related to CDMA system performance, is system frequency response. System frequency response is defined as variation of the ratio of input signal power to output signal power as a function of frequency. The system could be mobile-to-land, or land-to-mobile, or mobile-to-mobile.

A flat/near-flat frequency response system (in the range from 200 Hz to 3400 Hz), would be expected to have a higher perceived voice quality than a non-flat (high ripple about 10 dB) frequency response system. Hence measuring the frequency response of the system is a key factor in determining voice quality. Moreover, measuring frequency response of the individual sub-systems composing the overall system, helps isolate some voice quality problems that may occur.

The frequency response of the system is the plot of the normalized power (with respect to the power of the input tones), of the output tones versus frequency.

This test is a diagnostic test which could be used to troubleshoot voice quality problems.

Note: This test does not take into account acoustic properties of the handset ear-piece or microphone.

1.4.2 Method of measurement:

a. Configure the test as shown in figure 1.4.2-1

Note: Frequency response of breakout boxes and hybrid used in the following test must be known.

1) Mobile-to-land or land-to-mobile direction:

   a. Connect the mobile station to an audio-breakout box (analog or digital)

   b. Connect the land end to a telephone hybrid (analog or digital)

2) Mobile-to-mobile direction: connect the second mobile station to an another audio-breakout box (analog or digital)

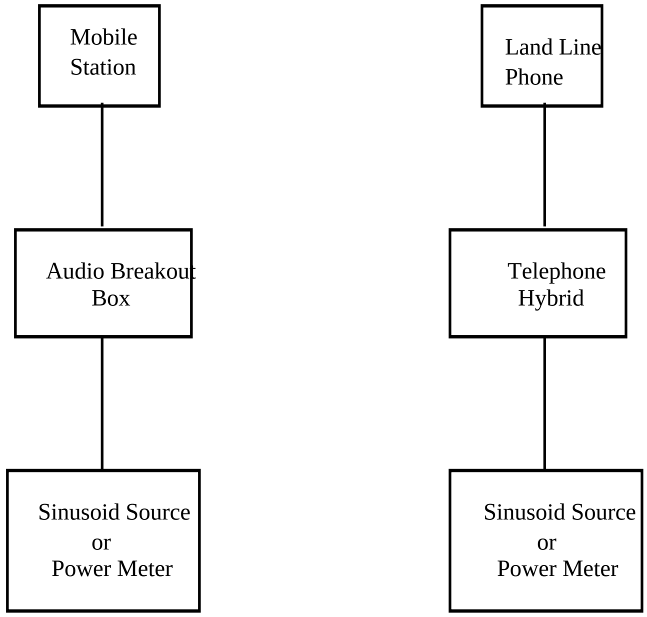


Figure 1.4.2-1 Functional Setup for Testing System Frequency Response

b. Connect a source of sinusoid of varying frequency with an average power equal to the nominal talk power (about -18 dBm0) to the audio-breakout box (in the case of mobile station-to-land or mobile station-to-mobile station) or connect the sinusoid source to the telephone hybrid (in the case of land-to-mobile station).

c. Connect an audio recording device to the telephone hybrid (in the case of Mobile station-to-land) or to audio-breakout box (in the case of land-to-mobile station) or to the second audio-breakout box (in the case of mobile station-to-mobile station).

d. Make a land-to-mobile station or mobile station-to-mobile station call at good RF condition (FER of 1% or less).

e. Using the sinusoid source, apply a tone at 100 Hz for a minimum of 200 ms, and record the received tone using the audio recording device.

f. Measure the power of the output tone.

g. Repeat steps d and e increasing the tone frequency by 10 Hz steps up to 4000 Hz.

1.4.3 Minimum Standard

Threshold of Acceptable Frequency Response performance (loop frequency response) is defined in ANSI/IEEE 820-1984

1.5 Frame Error Rate

1.5.1 Definition

This test is used to evaluate traffic channel performance of the CDMA system on the forward and reverse link in terms of statistical properties of erroneous data frames.

These statistics are obtained for comparative purposes between a lightly loaded system and a heavily loaded system, between mobile station implementations, and for observing the result of any other factors in the operating environment. The statistics may also be used for routine monitoring of CDMA system performance in an operating environment.

References:

IS-97A, Section 12.7

IS-126A, Loopback Service Options for Wideband Spread Spectrum Systems

1.5.2 Method of Measurement

a. The test is conducted for a mobile station moving on a prescribed drive or walk route. The drive route can be selected anywhere in a known good CDMA system coverage area. The test should include various vehicle speeds, stop signs, traffic lights and locations including close to the cell and medium distances in a variety of soft handoff conditions and no handoff. For a mobile station intended for hand-held use, a walking route should be used as well as any available vehicle adapter for the vehicle drive route.

b. Record the base station settings for full rate reverse link frame error rate (FER) target.

Note: The FER target may be attained by various different combinations of control parameters, such as E_b/N_o floor, ceiling, step size, time constant, etc. These parameters should be set at the discretion of the system operator.

c. Initiate a loopback service option call from the mobile station at the start of the drive or walk route. Traffic channel data used for the call should emulate the voice coder activity factor for conversational speech of approximately 48 %. This can be achieved by having the approximate frame rate distribution shown in Table 1.5.2-1

Note: In the example given in the following table, the overall voice activity factor is 47.52 %.

Note: Testing may be complemented using the Markov service option. When using the Markov service option, Markov data shall be transmitted on both the forward and reverse links.

Table 1.5.2-1 Approximate Frame Rate Distribution

Rate	Steady State Probability
Full	.3696
Half	.0475
Quarter	.0713
Eighth	.5116

d. Drive or walk the test route for a period of time that ensures a statistically significant number of data samples (recommended minimum of 15 minutes), while gathering FER statistics for the forward and reverse links.

Compute and record in the test report the following statistical data, based on blocks of 100 consecutive data frames.

1) Total number of whole 100-frame blocks in the test from which the statistics are obtained
2) Mean FER over the entire test, for each full data rate frame only
3) Number and percentage of 100 frame blocks with N full rate frame errors (N = 0, 1, 2, 3, ..., 100)
4) Charted histograms of the above FER percentages
5) Maximum burst length of full rate bad frames for the entire test

6) Number and percentage per unit of test time, of occurrences with N consecutive frame errors (N = 2, 3, 4, ...up to the maximum burst length recorded above). For example, if there were X occurrences of N consecutive bad frames over the total of T frames tested, the corresponding percentage is computed as (X * N / T) * 100.

7) Actual error patterns for the 3 worst frame groups (groups of 100 frames with the maximum number of full rate frame errors from the test set)

e. If the mobile station and base station support Rate Set 2, repeat test using Rate Set 2.

1.5.3 Minimum Standard

Statistical data for the forward and reverse links shall be computed and recorded in the test report. The target frame error rate for the reverse link shall be recorded in the test report.

2 MOBILE STATION TALK TIME/STANDBY TIME TESTS

2 .1 Mobile Station Talk Time

2.1.1 Definition

This test measures talk time of a mobile station by simulating typical conditions of a deployed system. The conditions include:

a. Mobile station transmitter power statistical profile obtained from the field data of several deployed CDMA systems.

b. Voice activity pattern typical of conversational speech.

c. Test is applicable to Class 3 for 800 MHz and Class 2 for 1900 MHz only.

2.1.2 Method of Measurement

a. Connect the mobile station to the base station simulator as shown in Figure 2.1.2-1.

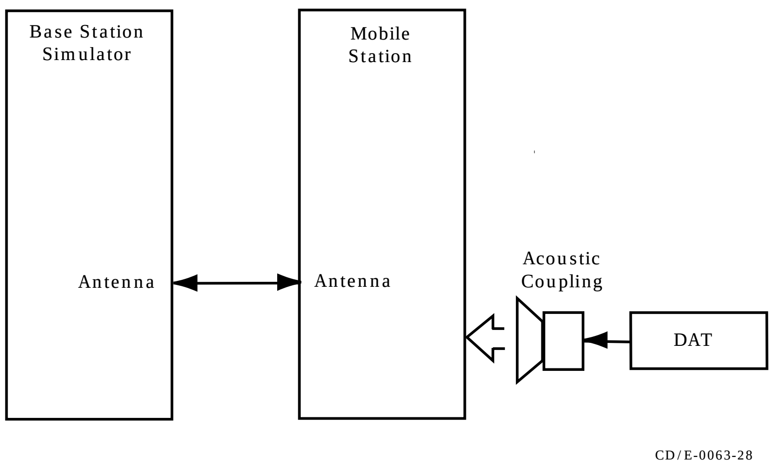


Figure 2.1.2-1 Functional Setup for Testing Mobile Station Talk Time

b. Ensure the mobile station is in a stabilized environment at 25 ????C nominal ambient temperature.

c. Ensure mobile station back lighting is permanently disabled, or set to the minimum on-time possible.

d. Set the base station simulator as shown in Table 2.1.2-1

Table 2.1.2-1 Base Station Simulator Settings

Parameter	Units	Value
I_{or}	dBm/1.23 MHz	-75
Pilot $\frac{E_c}{I_{or}}$	dB	-7
Traffic $\frac{E_c}{I_{or}}$	dB	-15

e. Observe the following mobile station battery requirements:

   1) Use an unused battery less than six months old.

   2) Charge the battery using the standard charger supplied to the consumer with the phone, in accordance with the manufacturer's instructions.

   3) Ensure a previously unused battery has been fully charged, fully discharged, then fully charged again.

f. Attach a fully charged battery to the mobile station.

g. Set the base station simulator to echo the voice from the mobile station.

h. Ensure the mobile station audio level is set to mid-range.

i. Power the mobile station on and originate a voice call while playing a 40% voice activity recording, and ensuring the audio level is at -18 dBm0.

j. Start the talk-time timer or have the base station simulator measure call duration.

Note: <40%harv.ZIP>, is a .wav file which contains a collection of Harvard sentences that have had silence added to them for 40% voice activity. It is provided for downloading on the CDG Members Only Web site, System Test Team area.

Note: Mobile station transmit power statistical profile summaries are shown in Tables 2.1.2-2 and 2.1.2-3, and Figures 2.1.2-2 and 2.1.2-3. They were generated by smoothing actual field test data from deployed CDMA units.

k. Have the base station control mobile station power per mobile station transmit power statistics in Table 2.1.2-2 for testing talk time in suburban topology, or in Table 2.1.2-3, for testing talk time in urban topology. Power control should occur as follows:

   1) The base station simulator shall control mobile station transmit power at 0 dBm.

   2) The base station simulator shall have a nominal dwell time of 2 seconds per each percent of probability in the applicable profile. At the end of each dwell time, the base station simulator shall control the mobile station at the next higher transmit power level. For example, if probability is 3.00% then dwell time shall be 6.00 sec.

   3) Once mobile station power has reached 23 dBm effective radiated power (ERP), the base station simulator shall dwell at that power level twice.

   Note: 200 mW or higher maximum power is assumed.

   4) The base station simulator shall then decrement the mobile station power in an analogous fashion until the minimum power level of -50 dBm is reached.

   5) When the minimum mobile station power listed in tables 2.1.2-2 and 2.1.2-3 is reached, the base station simulator shall dwell at that power level twice.

   6) Continue by alternately increasing and decreasing mobile station transmit power.

l. Continue the voice call until the battery is exhausted and the call is dropped. Stop the talk-time timer or have the base station simulator record call duration.

m. Repeat the entire procedure with different specimens of batteries and mobile stations for a minimum of 5 times to obtain average talk time.

n. If the mobile station supports rate set 2, repeat the test for rate set 2.

Table 2.1.2-2 Mobile Station Transmit Power Statistics (Preliminary)
(Suburban Topography)

Transmit Level	Probability	Transmit Level	Probability	Transmit Level	Probability
dBm	**%**	**dBm**	**%**	**dBm**	**%**
23	1.81%	-2	4.07%	-27	0.16%
22	1.45%	-3	4.09%	-28	0.14%
21	1.08%	-4	4.07%	-29	0.14%
20	0.90%	-5	4.01%	-30	0.13%
19	0.72%	-6	3.90%	-31	0.12%
18	0.60%	-7	3.75%	-32	0.11%
17	0.48%	-8	3.57%	-33	0.10%
16	0.50%	-9	3.35%	-34	0.09%
15	0.57%	-10	3.11%	-35	0.08%
14	0.68%	-11	2.85%	-36	0.06%
13	0.83%	-12	2.57%	-37	0.05%
12	1.01%	-13	2.16%	-38	0.05%
11	1.23%	-14	1.90%	-39	0.04%
10	1.47%	-15	1.65%	-40	0.03%
9	1.73%	-16	1.41%	-41	0.02%
8	2.01%	-17	1.19%	-42	0.02%
7	2.29%	-18	1.00%	-43	0.02%
6	2.57%	-19	0.82%	-44	0.02%
5	2.85%	-20	0.67%	-45	0.02%
4	3.11%	-21	0.54%	-46	0.02%
3	3.35%	-22	0.43%	-47	0.02%
2	3.57%	-23	0.34%	-48	0.02%
1	3.75%	-24	0.26%	-49	0.02%
0	3.90%	-25	0.20%	-50	0.02%
-1	4.01%	-26	0.17%		

The average mobile station power from the above profile is 11.5 mW (10.6 dBm).

Table 2.1.2-3 Mobile Station Transmit Power Statistics (Preliminary)
(Urban Topography)

Transmit Level	Probability	Transmit Level	Probability	Transmit Level	Probability
dBm	%	dBm	%	dBm	%
23	0.19%	-2	3.77%	-27	0.90%
22	0.21%	-3	4.25%	-28	0.84%
21	0.24%	-4	4.49%	-29	0.78%
20	0.27%	-5	4.18%	-30	0.73%
19	0.30%	-6	3.90%	-31	0.68%
18	0.34%	-7	3.64%	-32	0.63%
17	0.39%	-8	3.39%	-33	0.59%
16	0.43%	-9	3.16%	-34	0.55%
15	0.49%	-10	2.95%	-35	0.51%
14	0.55%	-11	2.75%	-36	0.48%
13	0.62%	-12	2.56%	-37	0.45%
12	0.70%	-13	2.39%	-38	0.42%
11	0.79%	-14	2.23%	-39	0.39%
10	0.89%	-15	2.08%	-40	0.36%
9	1.01%	-16	1.94%	-41	0.34%
8	1.14%	-17	1.81%	-42	0.31%
7	1.28%	-18	1.68%	-43	0.29%
6	1.44%	-19	1.57%	-44	0.27%
5	1.63%	-20	1.46%	-45	0.25%
4	1.83%	-21	1.37%	-46	0.24%
3	2.07%	-22	1.27%	-47	0.22%
2	2.33%	-23	1.19%	-48	0.21%
1	2.63%	-24	1.11%	-49	0.19%
0	2.96%	-25	1.03%	-50	0.18%
-1	3.34%	-26	0.96%		

The average mobile station power from the above profile is 3.5 mW (5.4 dBm).

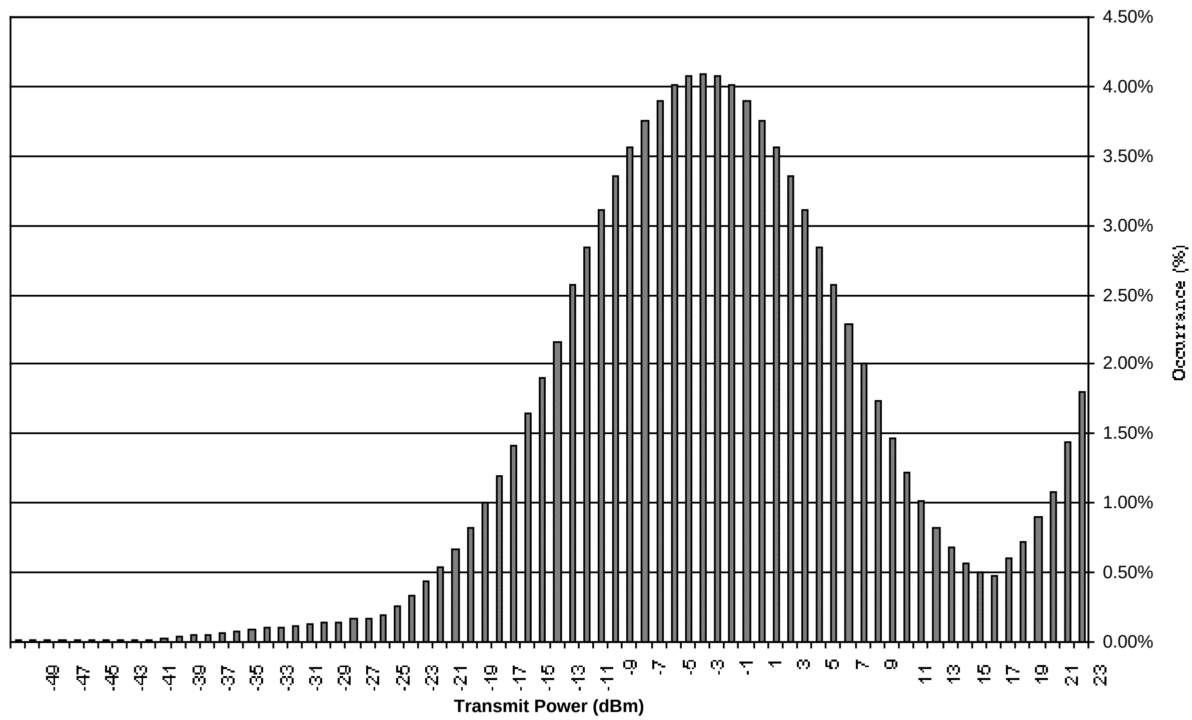


Figure 2.1.2-2 Probability Distribution of Mobile Station Transmit Power (Suburban Topography)

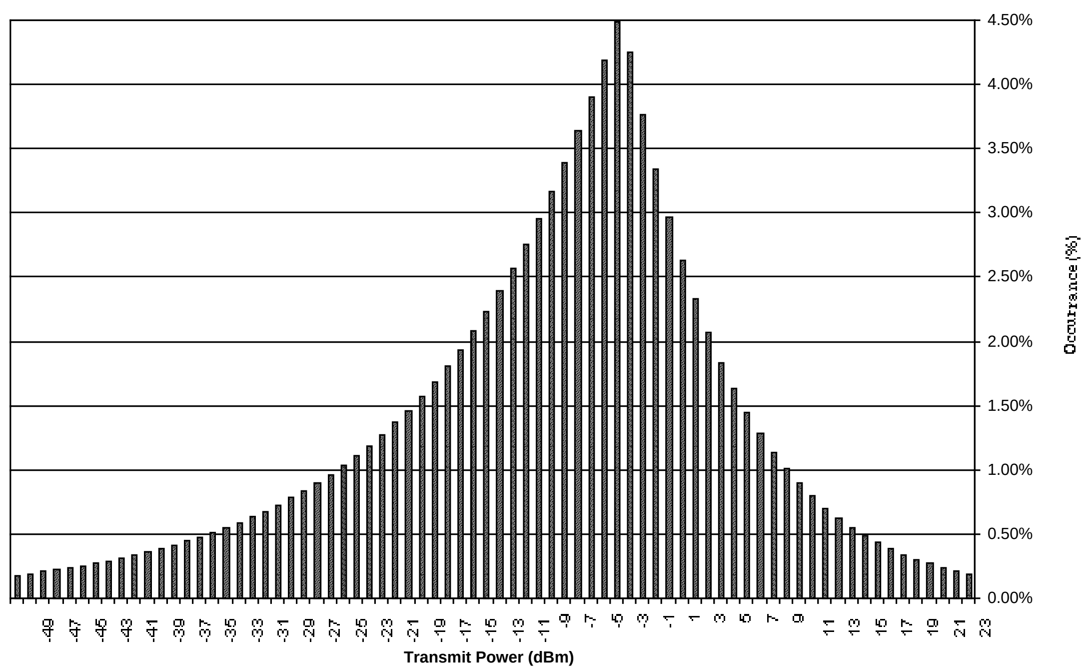


Figure 2.1.2-3 Probability Distribution of Mobile Station Transmit Power (Urban Topography)

2.1.3 Minimum Standard

Measured talk-time for the mobile station shall be recorded along with data on the type and nominal capacity of the battery used. Data obtained in this test provides the expected talk time in realistic field conditions. Real talk times experienced in the field may vary due to factors such as talk patterns and actual CDMA signal conditions.

2.2 Mobile Station Standby Time

2.2.1 Definition

This test measures the length of time that a mobile station can operate in standby mode on its internal battery power. It is assumed that a mobile station cannot establish a call if it's battery is completely drained. The test is performed for both high end and typical time. In the standby mode the mobile station has acquired the CDMA system and monitors the paging channel. Required conditions for the test include:

a. Slot cycle index is set to a specific fixed value by the base station, corresponding to the applicable paging slot cycle time.

b. Timer based registration is enabled, with the mobile station registering approximately every 52 minutes for typical time or 247 minutes for high end time testing.

c. An uninterrupted CDMA signal is present from the base station, of sufficient strength to eliminate repeated system acquisitions and resulting re-registrations.

2.2.2 Method of Measurement

a Connect the base station, mobile station and test equipment as shown in Figure 2.2.2-1

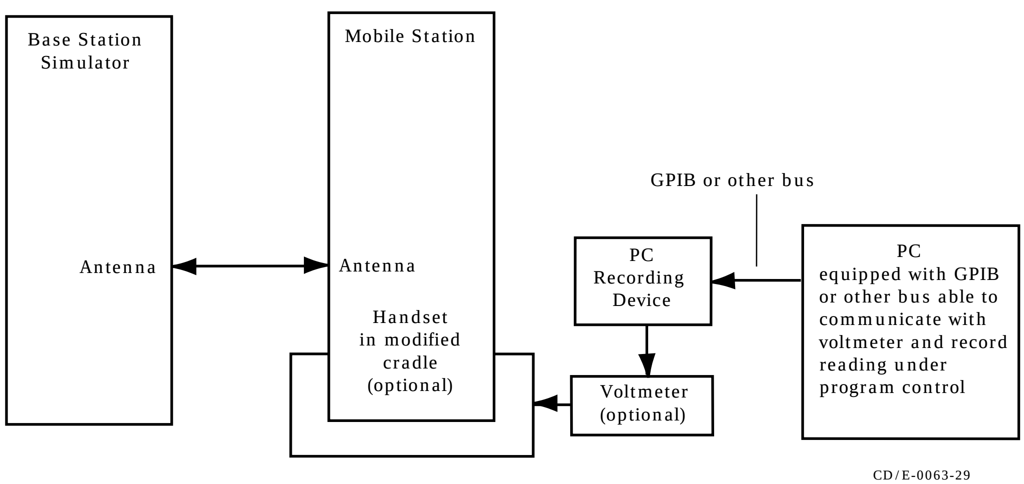


Figure 2.2.2-1 Functional Setup for Testing Mobile Station Standby Time

b. To measure typical standby time, configure the base station as follows:

1) Set REG_PRD to 61, corresponding to a registration period of approximately 52 minutes. All other forms of registration shall be disabled.

   Alternately, external timing may be used with an alternative registration procedure to yield a registration period of approximately 52 minutes.

2) Ensure the SLOT_CYCLE_INDEX in the mobile station and the MAX_SLOT_CYCLE_INDEX in the base station are such that the mobile station will use a slot cycle index of 1, corresponding to a slot cycle of 2.56 seconds.

3) Ensure an uninterrupted -75 dBm, 1.23 MHz CDMA signal from the base station, is received at the mobile station.

4) Set Neighbor List to include eight PN offsets, and set SEARCH WIN_A, SEARCH WIN_N and SEARCH WIN_R to eight.

5) Proceed to step d.

c. To measure high end standby time, configure the base station as follows:

1) Disable all registration forms except Power Registration.

2) Set REG_PRD to 70 corresponding to a registration period of approximately 247 minutes.

3) Ensure the SLOT_CYCLE_INDEX in the mobile station and the MAX_SLOT_CYCLE_INDEX in the base station are such that the mobile station will use a slot cycle index of 2, corresponding to a slot cycle of 5.12 seconds.

4) Ensure an uninterrupted -75 dBm, 1.23 MHz CDMA signal from the base station, is received at the mobile station.

5) Set Neighbor List to include eight PN offsets, and set SEARCH WIN_A, SEARCH WIN_N and SEARCH WIN_R to six.

d. Configure the mobile station as follows:

1) Ensure the mobile station is in a stabilized environment at 25 ±5° C nominal ambient temperature.

2) Permanently disable mobile station back lighting or set it to the minimum.

e. Observe the following mobile station battery requirements:

1) Use an unused battery less than six months old.

2) Charge the battery using the standard charger supplied to the consumer with the phone, in accordance with the manufacturer's instructions.

3) Ensure a previously unused battery has been fully charged, fully discharged, then fully charged again.

f. Attach a fully charged battery to the mobile station.

g. Power up the mobile station and start the standby timer.

Note: The mobile station battery voltage may optionally be recorded approximately every ten minutes for the duration of the test. Voltage measurements should preferably not be made in coincidence with registrations.

h. Monitor the mobile station battery until the battery is discharged and the mobile station powers down. Stop the standby-time timer.

Note: For most batteries, at the time the mobile station powers down due to insufficient battery voltage, the optionally recorded voltage will cease to drop and will rise as a result of the reduced current drain. See Figure 2.2.2-2

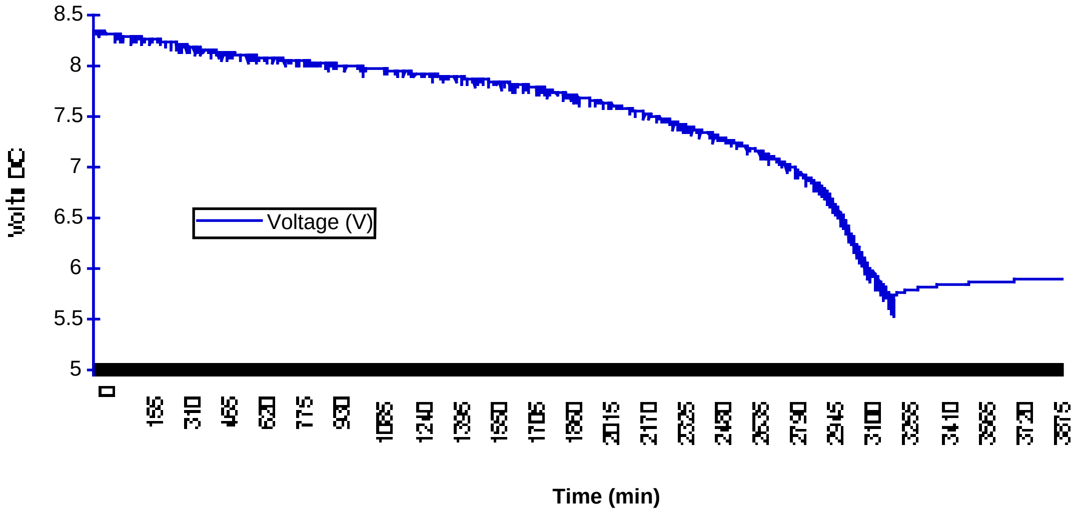


Figure 2.2.2-2 Example of Battery Voltage Variation in Standby Time Test

i. Repeat the entire procedure for each scenario with different specimens of batteries and mobile stations, a minimum of 5 times to obtain average standby time.

2.2.3 Minimum Standard

Measured standby time for the mobile station for both high end and typical time shall be recorded along with data on the type and nominal capacity of the battery used. Data obtained in the test provides the standby time that should be expected. Real standby times experienced in the field may vary due to factors such as registration activity of the mobile station and slot cycle index used in the network.

3 DATA SERVICES

3.1 Source Port Correctness

3.1.1 Definition

This test verifies the local TCP session uses different source port numbers between subsequent connections. This is done by demonstrating there are no problems in establishing data calls in rapid succession.

Traceability: IS-99 3.3 and IS-707

Applicability: SO4, SO12, SO5 and SO13

3.1.2 Method of Measurement

a. Place a data call from $TE2_M$ to $TE2_L$.

b. Verify characters typed at $TE2_M$ can be viewed at $TE2_L$. Verify characters typed at $TE2_L$ can be viewed at $TE2_M$.

c. Attenuate the forward traffic channel so the receive signal falls below the mobile station's receiver sensitivity threshold, and the call drops.

d. Reduce the attenuation so that the forward traffic channel is restored to its nominal frame error rate of no greater than 1%. Immediately perform step e.

e. Place a data call from $TE2_M$ to $TE2_L$.

f. Verify characters typed at $TE2_M$ can be viewed at $TE2_L$. Verify characters typed at $TE2_L$ can be viewed at $TE2_M$.

g. Repeat the test using two mobile terminated calls.

3.1.3 Minimum Standard

a. The follow-up call shall be successfully established.

b. Data transfer on the follow-up call (step e) shall be complete and accurate.

4 PREFERRED ROAMING LIST

4.1 Preferred Roaming List, Positive Entry Test

4.1.1 Definition

This test measures how long the mobile station takes to acquire the system under various signal conditions when moving from a home to a roaming environment using a positive entry from a carrier supplied Preferred Roaming List (PRL) made up of multiple SID/NID combinations.

A detailed repeatable test plan should be agreed upon in writing so that multiple participants can accomplish this test in parallel. There may be many possible combinations to test in order to establish validity of the algorithm.

Traceability

4.1.2 Method of Measurement

The carrier shall supply a test PRL containing a number of positive entries. The number of PRL (SID, NID) entries, and order of the list shall be designated by the carrier. The PRL shall contain one entry from the home system. The PRL list should be long enough to allow for timing measurements to be made.

a. If the mobile station supports historical channel information, it shall be set to the default value.

b. Select a drive/walk route which takes into account network boundaries, various signal levels, multiple roaming partners, and PRL order, etc. as the carrier shall direct.

c. Activate the mobile station on a system reflected in the PRL (SID, NID) pairs.

d. Power up the mobile station and commence timing.

e. Stop timing when the mobile station has acquired a system from the PRL loaded into the test unit.

f. Make a test call to verify the mobile station has acquired the right system.

g. Multiple tests should be run to establish minimum/maximum and average acquisition times.

Note: Acquisition time could be affected by handset programming. Therefore a number of similarly programmed handsets should be used to establish average acquisition time.

Note: The first acquisition may be different from subsequent acquisitions of a given SID/NID because the mobile station acquisition algorithm may be using historical information to improve its acquisition speed. Home SID/NID acquisition time may be different than roaming acquisition time.

4.1.3 Minimum Standard

The minimum standard shall be determined by the carrier, based on market requirements.

4.2 Emergency Call On a System that is Negative on PRL

4.2.1 Definition

The purpose of this test is to demonstrate that a mobile station which contains a negative entry in its Preferred Roaming List (PRL), can place an emergency call on that negatively listed system.

Traceability

TIA 683-A, IS683-A 3.5

4.2.2 Method of Measurement

a. Connect the mobile station and base station as shown in Figure 4.2.2-1.

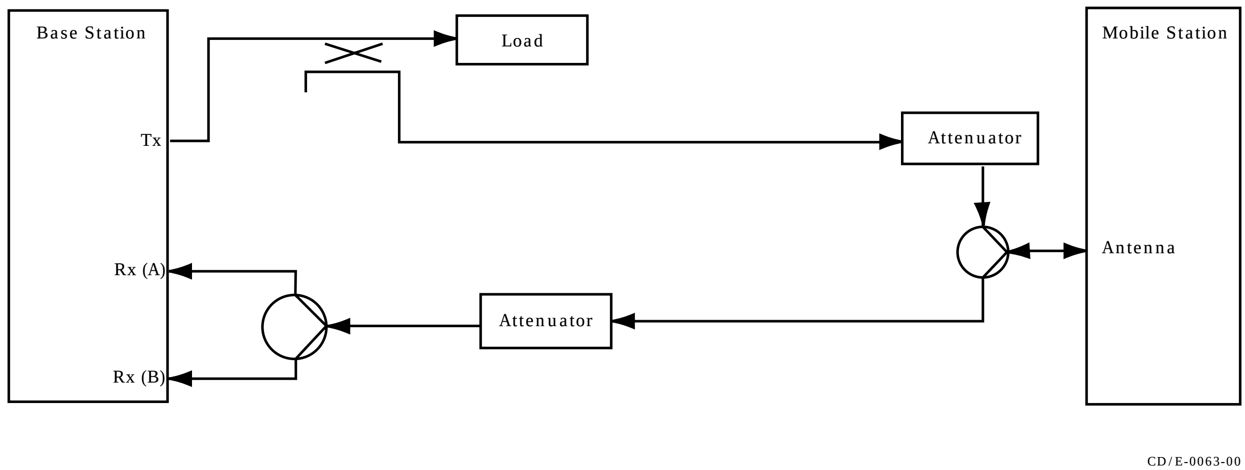


Figure 4.2.2-1 Functional Setup for Testing an Emergency Call On a System that is Negative on PRL

b. Program the mobile station PRL with a single entry in the negative PRL corresponding to the base station's (SID, NID). This (SID, NID) pair is subsequently referred to as (SID, NID) $_{NEG}$.

c. Enable power-up registration. Disable all other forms of registration.

d. Ensure the base station does not broadcast a Global Service Redirection Message which would prevent the mobile station from acquiring this base station system.

e. Power on the mobile station, and monitor it for a sufficient period of time to permit it to acquire the CDMA system (typically 30 seconds). Verify the mobile station does not send any Registration Messages during this time. Verify the mobile station indicates a NO-SERVICE condition.

Note: Depending on the band classes it supports, it may take some time for the mobile station to attempt acquisition of all possible frequency blocks in all the band classes. Monitor the mobile station until a full cycle of acquisition attempts has been completed.

f. Place an emergency call from the mobile station (911 in the United States). Verify the mobile station generates an Origination Message to the (SID, NID) $_{NEG}$ base station. Verify the emergency call is routed to the Public Service Answering Point (PSAP) or equivalent emulation unit.

g. End the emergency call from the mobile station.

4.2.3 Minimum Standard

4.2.3.1 Prior to placing an emergency call:

a. The mobile station shall not register on the (SID, NID) $_{NEG}$ system.

4.2.3.2 After placing an emergency call:

a. The emergency call shall be placed on (SID, NID) $_{NEG}$ system and shall be successful.

b. The emergency call shall be routed to the appropriate PSAP or corresponding PSAP emulation unit.

4.3 System Acquisition

4.3.1 Definition

The purpose of this test is two fold:

a. To determine how much time is required for a mobile station to acquire a system for the first time.

b. To determine whether a mobile station will use information from a previous system acquisition to decrease the time required to re acquire the same system.

Traceability

The mobile station functionality being tested is not covered by any written standard and therefore, will be run solely at the discretion of carriers.

4.3.2 Method of Measurement

Carriers requiring this test will supply provisioning information that matches the CDMA channel, SID, NID, etc. being transmitted by the base station simulator. The provisioning information will be loaded into the test mobile by any means which both the carrier and the mobile station vendor agree.

a. Clear mobile station acquisition history so that previously stored system acquisition information is erased, then power off the mobile station.

b. Connect the mobile station to the base station simulator.

c. Enable the output of the base station simulator.

d. Power on the mobile station and measure the elapsed time between pressing the power key, and appearance of the system acquisition indication on the mobile station.

e. Power off the mobile station.

f. Repeat step d to determine the time required to re acquire the same system.

g. Record the difference between the time required to initially acquire the system and the time required to re acquire the system.

h. Clear mobile station acquisition history so that previously stored system acquisition information is erased, then power off the mobile station.

i. Repeat steps d through h until a reasonable estimate of both initial acquisition time and the delta between initial acquisition time and system re acquisition time is established.

4.3.4 Minimum Standard

There is no minimum standard defined for this test. Pass/fail criteria shall be determined solely by the carrier.

APPENDIX A: MOS-PREDICTIVE TEST TECHNIQUE EVALUATION PROCEDURE

A.1 Procedure

A.1.1 Definition

The purpose of the test is to qualify a (D)MOS-predictive test technique for limited use in evaluating audio quality in CDMA networks.

This procedure defines the process of evaluation of a (D)MOS-predictive test technique (a technique which claims to predict Mean Opinion Score or Degradation Mean Opinion Score). The technique is evaluated in terms of level of correlation that the method exhibits in grading given speech material by subjective Mean-Opinion Scoring (MOS) or Degradation Mean Opinion Scoring (DMOS), depending on the technique algorithm.

A.1.2 Method of Measurement

a. Obtain the source material for (D)MOS-predictive test evaluation. The source material can be obtained from the CDG. Additional or alternative source material may be generated by a system operator seeking certification of a (D)MOS-predictive test method. In that case, the source material preparation should meet the guidelines outlined in Section A.3.

   The source material consists of two parts corresponding to the five subjective tests within the three phases of certification, as outlined in Section A.3. The quiet source material is usable for Experiments 3-1, 4-1, and 5-1 (a subset of that for 4-1), and the noisy source material is usable for Experiments 4-2 and 5-2 (a subset of that for 4-2). The procedure itself is the same for all three phases.

b. Load the Original Set O(n) and the Reproduced Set R(n) of test sentences into (D)MOS Predictive test recording device, as required for the operation of the (D)MOS-predictive technique.

c. Perform any necessary calibration of the test equipment.

d. Start the (D)MOS-Predictive test run, ensuring that any call setup required in the real-time drive testing is bypassed.

e. Replay the entire recorded material while grading each sentence-pair separately and recording the grade of each set element.

f. Save all score data at the conclusion of test.

g. Provide the source material files, the impaired material files, and the predicted (D)MOS scores for each sentence-pair file processed for each vocoder/condition to an impartial evaluation lab or institution designated by CDG. The institution will score them using an unbiased subjective method, correlate the subjective and objective test results, and issue a certificate that states the product code name and (D)MOS predictive correlation level.

h. The CDG designated lab will compute all results and data listed in the Minimum Standard for this procedure. The subjective (D)MOS grading process itself is outlined in Section A.4.

A.1.3 Minimum Standard

a. (D)MOS-predictive test technique should demonstrate a level of correlation with the subjective (D)MOS of no less than 85%. Correlation computation is defined in Section A.2.2.

b. Repeatability of (D)MOS predictive scores for each test condition in tables A.3.3-1, A.3.4-1 and A.3.5-1 should not exceed the repeatability of subjective (D)MOS for the same set by more than 0.3 points. Repeatability is defined in Section A.2.1.

c. Weighted average repeatability of (D)MOS predictive scores for all test conditions in tables A.3.3-1, A.3.4-1 and A.3.5-1 should not exceed the subjective (D)MOS weighted average repeatability by more than 0.3 points.

d. Actual correlation level, and individual and weighted average repeatability shall be disclosed in the evaluation report for this test.

A.2 Definitions

A.2.1 Repeatability

Repeatability is defined as the spread of (D)MOS scores for a set of conditions in each row of tables A.3.3-1, A.3.4-1 and A.3.5-1. Average repeatability is the weighted average (by number of sentences) for all rows of that table.

For example, if the 5 tests in row 4 of Table A.3.5-1 (Q13-full codec with 1 - 2 % FER in the reverse link and 12 dB car and babble noise suppression), were graded as follows: 3.94, 4.02, 3.88, 4.31 and 4.19, then the repeatability of that subset is the difference between the highest grade and the lowest grade, i.e.

4.31 - 3.88 = 0.43

This repeatability would enter into computation of average repeatability with a weight of 5%, since this subset represents 5% of all evaluation tests.

A.2.2 Correlation

Correlation C between the subjective (D)MOS sequence X(n) and predicted MOS sequence Y(n) is defined as:

$$C = \frac{1}{(M-1) * \sigma_X * \sigma_Y} * \sum_{n=1}^{M} \left\{ \left[X(n) - \overline{x} \right] * \left[Y(n) - \overline{y} \right] \right\}$$

where:

M . . . . number of samples

$\overline{x}, \overline{y}$ . . . . mean values of sequences X(n) and Y(n) respectively

σ_X, σ_Y . . standard deviations of sequences X(n) and Y(n) respectively

A.3 Preparation of Source Material

A.3.1 Definition of Terms

A.3.1.1 Sentence-Pair

The smallest practical segment of source material for which an Opinion Score can be obtained, is about 7 to 8 seconds long. Sentence-pairs are recommended for speech-quality assessments, since single sentences are normally too short to produce reliable subjective (D)MOS values.

A.3.1.2 Call Set Sample

The segment of speech used for (D)MOS evaluation, consists of multiple sentence-pairs. A call set sample is usually about 2 minutes long, which represents a phone call of average duration.

A.3.2 (D)MOS-Predictive Input Material Content

Input material used for obtaining the (D)MOS-predictive values consists of two sets of speech samples:

a. O(n), n = 1 ... M, is the Original Set of call samples, and contains Harvard sentence-pairs recorded by a variety of speakers.

b. R(n), n = 1 ... M, is the Reproduced Set of call samples in the original set (1), recorded after transmission over CDMA channel.

The reproduced set is obtained by introduction of various impairments. There are some differences among the three phases of evaluation in the way impairments are induced, as outlined. Impairments include one or more of the following:

a. Voice encoding and decoding by means of several CDMA standard voice codecs.

b. Transmission over a CDMA channel on the forward and reverse link, which are subject to transmission errors.

c. Injection of background noise on the speaker side, including office noise, car noise and babble.

In each phase of evaluation, each assembly O(n) and R(n) should have 96 sentence-pairs as a minimum.

Playing source material sets and recording processed material sets should be accomplished by means of file-oriented computer storage interfaced by D/A and A/D conversion with audio interfaces to the terminal equipment, without acoustic conversion.

The analog electrical audio signal on the send and receiving ends should be connected directly into the file-oriented playback and recording devices.

A.3.3 (D)MOS-Predictive Input Material Obtained by Channel Simulation

In the first phase of evaluation, (D)MOS-predictive input material is obtained by computer simulation of the analog audio processing, vocoder processing including double vocoding, and CDMA channel errors.

Source material for this phase consists of the basic six source material "packets", each "packet" comprising two unique sentence-pairs for each of the four male and four female talkers. Each "packet" is approximately 2 minutes in total overall length. All six "packets will need to be processed through each of the vocoder/conditions for use in the subjective and objective assessments.

Sentence-pairs in the R(n) set are catalogued by types of impairments induced by computer simulation runs, as shown in Table A.3.3-1. Codec combinations (tandems) are denoted with a slash. For example EVRC/IS96-A means that a sentence-pair is processed encoding and decoding first with EVRC then with IS95-A.

Note: When using an Audio Break-Out Box, the electrical interface must emulate the frequency response of the electric-acoustic coupling to the phone. Failure to emulate the frequency response of the electric-acoustic coupling will distort the results of the subjective MOS test and the (D)MOS-predictive measurements.

In the subjective evaluation, each of 12 groups of four listeners will assess eight uniquely randomized presentation sets of 32 test elements. Within the total 96 unique presentation sets, each test element will be represented by a unique talker/sentence-pair. In this manner, each listener will assess 256 total test elements in order to achieve 384 votes per test element, across the complete MOS or DMOS listening test.

Within an MOS listening test, each pertinent sample will be presented to the listeners by itself, and the listeners asked to rate the perceived quality of the presented sample. Within a DMOS listening test, each pertinent sample will be preceded in the presentation to the listeners by an associated source sample, and the listeners will be asked to rate the perceived quality degradation of the processed sample relative to the source sample.

Table A.3.3-1 Simulated Impairments for Reproduced Set of Harvard Sentences

No.	# Sentence-Pairs	CODEC	FER (%)
1	96	Q13-full	0 %
2	96	Q13-full	2 %
3	96	Q13-full	4 %
4	96	Q13-full	8 %
5	96	Q13-full	10 %
6	96	Q13-12	4 %
7	96	Q13-11	8 %
8	96	Q13/IS-96-A	0 %
9	96	Q13/IS-96-A	4 %
10	96	Q13/EVRC	0 %
11	96	Q13/EVRC	4 %
12	96	IS-96-A	0 %
13	96	IS-96-A	2 %
14	96	IS-96-A	4 %
15	96	IS-96-A	8 %
16	96	IS-96-A	10 %
17	96	IS-96-A/Q13	0 %
18	96	IS-96-A/Q13	4 %
19	96	EVRC	0 %
20	96	EVRC	2 %
21	96	EVRC	4 %
22	96	EVRC	8 %
23	96	EVRC	10 %
24	96	EVRC/IS-96-A	0 %
25	96	EVRC/IS-96-A	4 %
26	96	Source	N/A
27	96	MNRU Q36	N/A
28	96	MNRU Q30	N/A
29	96	MNRU Q24	N/A

30	96	MNRU Q18	N/A
31	96	MNRU Q12	N/A
96	96	MNRU Q06	N/A

A.3.4 (D)MOS-Predictive Input Material Obtained by Impairments Induced in the Lab

In the second phase of evaluation. (D)MOS-predictive input material is obtained by an actual mobile station and a base station in the controlled environment in the lab. The main objective of the lab validation is to determine the (D)MOS-predictive algorithm viability in dealing with real and controlled impairments which can be produced in lab conditions. The environment can be tightly controlled, producing a wide variety of conditions spanning the useful spectrum of impairments, including injected office noise, car noise and babble noise.

The source material for this phase consists of the basic six source material "packets", each "packet" comprising two unique sentence-pairs for each of the four male and four female talkers. Each "packet" is approximately 2 minutes in total overall length. All six "packets" will need to be processed through each of the vocoder/conditions for use in the subjective and objective assessments.

Sentence-pairs in the R(n) set are catalogued by types of impairments induced in the lab, as shown in Table A.3.4-1. Codec combinations (tandems) are denoted with a slash. For example EVRC/IS95-A means that a-sentence-pair is processed encoding and decoding first with EVRC then with IS95-A.

Note: When using an Audio Break-Out Box, the electrical interface must emulate the frequency response of the electric-acoustic coupling to the phone. Failure to emulate the frequency response of the electric-acoustic coupling will distort the results of the subjective MOS test and the (D)MOS-predictive measurements.

In the subjective evaluation, each of 12 groups of four listeners will assess eight uniquely randomized presentation sets of 96 test elements. Within the total 96 unique presentation sets, each test element will be represented by a unique talker/sentence-pair. In this manner, each listener will assess 256 total test elements in order to achieve 384 votes per test element, across the complete MOS or DMOS listening test.

Within a MOS listening test, each pertinent sample will be presented to the listeners by itself, and the listeners will be asked to rate the perceived quality of the presented sample. Within a DMOS listening test, each pertinent sample will be preceded in the presentation to the listeners by an associated source sample, and the listeners will be asked to rate the perceived quality degradation of the processed sample relative to the source sample.

Table A.3.4-1 Lab Test Conditions for Reproduced Set of Harvard Sentences

No.	# Sentence-Pairs	CODEC	FER (%)	RF Link
1	96	Q13-full	0 %	FWD
2	96	Q13-full	0 %	REV
3	96	Q13-full	2 %	REV
4	96	Q13-full	2 - 4 %	REV
5	96	Q13-full	8 %	REV
6	96	Q13-12	4 %	FWD
7	96	Q13-11	8 %	REV
8	96	Q13/IS-96-A	0 %	REV
9	96	Q13/IS-96-A	4 %	REV
10	96	Q13/EVRC	0 %	REV
11	96	Q13/EVRC	4 %	REV
12	96	IS-96-A	0 %	FWD
13	96	IS-96-A	0 %	REV
14	96	IS-96-A	2 %	FWD
15	96	IS-96-A	2 - 4 %	REV
16	96	IS-96-A	8 %	REV
17	96	IS-96-A/Q13	0 %	REV
18	96	IS-96-A/Q13	4 %	REV
19	96	EVRC	0 %	FWD
20	96	EVRC	0 %	REV
21	96	EVRC	2 %	REV
22	96	EVRC	2 - 4 %	REV
23	96	EVRC	8 %	REV
24	96	EVRC/IS-96-A	0 %	REV
25	96	EVRC/IS-96-A	4 %	REV
26	96	Source	N/A	N/A
27	96	MNRU Q36	N/A	N/A
28	96	MNRU Q30	N/A	N/A
29	96	MNRU Q24	N/A	N/A

30	96	MNRU Q18	N/A	N/A
31	96	MNRU Q12	N/A	N/A
32	96	MNRU Q06	N/A	N/A

Table A.3.4-2 Lab Test Conditions for Reproduced Set of Harvard Sentences

No.	# Sentence-Pairs	CODEC	FER (%)	RF Link	S/N Office (dB)	S/N Car (dB)	S/N Babble (dB)
1	96	Q13-full	0 %	FWD	20 dB	N/A	N/A
2	96	Q13-full	0 %	REV	N/A	12 dB	N/A
3	96	Q13-full	0 %	REV	N/A	N/A	12 dB
4	96	Q13-full	2 - 4 %	REV	N/A	12 dB	N/A
5	96	Q13-full	2 - 4 %	REV	N/A	N/A	12 dB
6	96	Q13-12	4 %	FWD	20 dB	N/A	N/A
7	96	Q13-11	8 %	REV	N/A	12 dB	N/A
8	96	IS-96-A	0 %	FWD	20 dB	N/A	N/A
9	96	IS-96-A	0 %	REV	N/A	12 dB	N/A
10	96	IS-96-A	0 %	REV	N/A	N/A	12 dB
11	96	IS-96-A	2 - 4 %	REV	N/A	12 dB	N/A
12	96	IS-96-A	2 - 4 %	REV	N/A	N/A	12 dB
13	96	EVRC	0 %	FWD	20 dB	N/A	N/A
14	96	EVRC	0 %	REV	N/A	12 dB	N/A
15	96	EVRC	0 %	REV	N/A	N/A	12 dB
16	96	EVRC	2 - 4 %	REV	N/A	12 dB	N/A
17	96	EVRC	2 - 4 %	REV	N/A	N/A	12 dB
18	96	Source	N/A	N/A	20 dB	N/A	N/A
19	96	Source	N/A	N/A	N/A	12 dB	N/A
20	96	Source	N/A	N/A	N/A	N/A	12 dB
21	96	MNRU Q30	N/A	N/A	20 dB	N/A	N/A
22	96	MNRU Q24	N/A	N/A	N/A	12 dB	N/A
23	96	MNRU Q24	N/A	N/A	N/A	N/A	12 dB
24	96	MNRU Q24	N/A	N/A	20 dB	N/A	N/A
25	96	MNRU Q18	N/A	N/A	N/A	12 dB	N/A
26	96	MNRU Q18	N/A	N/A	N/A	N/A	12 dB
27	96	MNRU Q18	N/A	N/A	20 dB	N/A	N/A
28	96	MNRU Q12	N/A	N/A	N/A	12 dB	N/A
29	96	MNRU Q12	N/A	N/A	N/A	N/A	12 dB

30	96	MNRU Q12	N/A	N/A	20 dB	N/A	N/A
31	96	MNRU Q06	N/A	N/A	N/A	12 dB	N/A
32	96	MNRU Q06	N/A	N/A	N/A	N/A	12 dB

A.3.5 (D)MOS-Predictive Input Material Obtained by Impairments Induced in the Field

In this final phase of evaluation, (D)MOS-predictive input material is obtained by performing tests in the field with an actual mobile station in a deployed system. The objective of the field test validation is to determine the (D)MOS-predictive algorithm behavior when faced with a combination of effects encountered in the real system, including injected office noise, car noise and babble noise. The lack of ability to control the channel environment during the source material acquisition test runs is not important, since the (D)MOS scores will be compared between the candidate (D)MOS-predicting equipment and the subjective (D)MOS scores, no matter what the environment.

The source material for this phase consists of the basic six source material "packets", each "packet" comprising two unique sentence-pairs for each of the four male and four female talkers. Each "packet" is approximately 2 minutes in total overall length. All six "packets" will need to be processed through each of the vocoder/conditions for use in the subjective and objective assessments.

Sentence-pairs in the R(n) set are catalogued by types of impairments present in the field connections, as shown in Table A.3.5-1. The FER values catalogued in Table A.3.5-1 don't need to be met exactly. The approximate values can be reached by performing an extensive test run, then searching for segments that meet the FER criteria outlined.

Note: When using an Audio Break-Out Box, the electrical interface must emulate the frequency response of the electric-acoustic coupling to the phone. Failure to emulate the frequency response of the electric-acoustic coupling will distort the results of the subjective MOS test and the (D)MOS-predictive measurements.

In the subjective evaluation, each of 12 groups of four listeners will assess eight uniquely randomized presentation sets of 24 test elements. Within the total 96 unique presentation sets, each test element will be represented by a unique talker/sentence-pair. In this manner, each listener will assess 192 total test elements in order to achieve 384 votes per test element, across the complete MOS or DMOS listening test.

Within an MOS listening test, each pertinent sample will be presented to the listeners by itself, and the listeners will be asked to rate the perceived quality of the presented sample. Within a DMOS listening test, each pertinent sample will be preceded in the presentation to the listeners by an associated source sample, and the listeners will be asked to rate the perceived quality degradation of the processed sample relative to the source sample.

Table A.3.5-1 Field Test Conditions for Reproduced Set of Harvard Sentences

No.	# Sentence-Pairs	CODEC	FER (%)	RF Link
1	96	Q13-full	< 1 %	FWD
2	96	Q13-full	< 1 %	REV
3	96	Q13-full	1 - 2 %	REV
4	96	Q13-full	2 - 4 %	REV
5	96	Q13-full	> 4 %	REV
6	96	Q13-12	2 - 4 %	FWD
7	96	Q13-11	> 4 %	REV
8	96	IS-96-A	< 1 %	FWD
9	96	IS-96-A	< 1 %	REV
10	96	IS-96-A	1 - 2 %	FWD
11	96	IS-96-A	2 - 4 %	REV
12	96	IS-96-A	> 4 %	REV
13	96	EVRC	< 1 %	FWD
14	96	EVRC	< 1 %	REV
15	96	EVRC	1 - 2 %	REV
16	96	EVRC	2 - 4 %	REV
17	96	EVRC	> 4 %	REV
18	96	Source	N/A	N/A
19	96	MNRU Q36	N/A	N/A
20	96	MNRU Q30	N/A	N/A
21	96	MNRU Q96	N/A	N/A
22	96	MNRU Q18	N/A	N/A
23	96	MNRU Q12	N/A	N/A
24	96	MNRU Q06	N/A	N/A

Table A.3.5-2 Field Test Conditions for Reproduced Set of Harvard Sentences

No.	# Sentence-Pairs	CODEC	FER (%)	RF Link	S/N Office (dB)	S/N Car (dB)
1	96	Q13-full	< 1 %	FWD	20 dB	N/A
2	96	Q13-full	1 - 2 %	REV	N/A	12 dB
3	96	Q13-full	2 - 4 %	REV	N/A	12 dB
4	96	Q13-full	> 4 %	REV	N/A	12 dB
5	96	Q13-12	2 - 4 %	FWD	20 dB	N/A
6	96	Q13-11	> 4 %	REV	N/A	12 dB
7	96	IS-96-A	< 1 %	FWD	20 dB	N/A
8	96	IS-96-A	1 - 2 %	REV	N/A	12 dB
9	96	IS-96-A	2 - 4 %	REV	N/A	12 dB
10	96	IS-96-A	> 4 %	REV	N/A	12 dB
11	96	EVRC	< 1 %	FWD	20 dB	N/A
12	96	EVRC	1 - 2 %	REV	N/A	12 dB
13	96	EVRC	2 - 4 %	REV	N/A	12 dB
14	96	EVRC	> 4 %	REV	N/A	12 dB
15	96	Source	N/A	N/A	20 dB	N/A
16	96	Source	N/A	N/A	N/A	12 dB
17	96	MNRU Q30	N/A	N/A	20 dB	N/A
18	96	MNRU Q96	N/A	N/A	N/A	12 dB
19	96	MNRU Q96	N/A	N/A	20 dB	N/A
20	96	MNRU Q18	N/A	N/A	N/A	12 dB
21	96	MNRU Q18	N/A	N/A	20 dB	N/A
22	96	MNRU Q12	N/A	N/A	N/A	12 dB
23	96	MNRU Q12	N/A	N/A	20 dB	N/A
24	96	MNRU Q06	N/A	N/A	N/A	12 dB

A.4 Subjective (D)MOS Grading

Each element in the reproduced set R(n) is graded by averaging scores of S subjects on a scale from 1 to 5 to obtain sets of grades X(n), for example:

$X(n) = \overline{MOS\left[R(n)\right]}$ n = 1, ... M

The recommended minimum number of listening subjects is S = 48.

The set Y(n) is the corresponding set of grades of the reproduced set R(n) obtained from the (D)MOS-predictive test equipment being evaluated. The sets X(n) and Y(n) are used in computing the subjective (D)MOS vs (D)MOS-predictive correlation defined in Section A.2.2.

APPENDIX B: (D)MOS EXAMPLE TEST SENTENCES

Set 1

It seems simple to my mind.

She said that she adored men.

You will have to be very quiet.

There was nothing to be seen.

Would you please give us the facts?

Set 2

He arrived home every night

You were the perfect hostess

He punched viciously at the ball

She was so interested in it

I want a minute with the inspector

Set 3

The birch canoe slid on the smooth planks

Glue the sheet to the dark blue background

It's easy to tell the depth of a well

Four hours of steady work faced us

A large size in stockings is hard to sell

Set 4

The juice of lemons makes fine punch

The box was thrown beside the parked truck

The hogs we fed chopped corn and garbage

These days a chicken leg is a rare dish

Rice is often served in round bowls

Set 5

The boy was there when the sun rose

A rod is used to catch pink salmon

The source of the huge river is the clear spring

Kick the ball straight and follow through

Help the woman get back to her feet

Set 6

A pot of tea helps to pass the evening

Smoky fires lack flame and heat

The soft cushion broke the man's fall

The salt breeze came across from the sea

The girl at the booth sold fifty bonds

Set 7

The small pup gnawed a hole in the sock

The fish twisted and turned on the bent hook

Press the pants and sew a button on the vest

The swan dive was far short of perfect

The beauty of the view stunned the young boy

Set 8

Two blue fish swam in the tank

Her purse was full of useless trash

The colt reared and threw the tall rider

It snowed, and rained, and hailed the same morning

Read verse out loud for pleasure

Set 9

Hoist the load to your left shoulder

Take the winding path to reach the lake

Note closely the size of the gas tank

Wipe the grease off his dirty face

Mend the coat before you go out

Set 10

Name a large steamer that sails from this port

James tried his best to gain ground

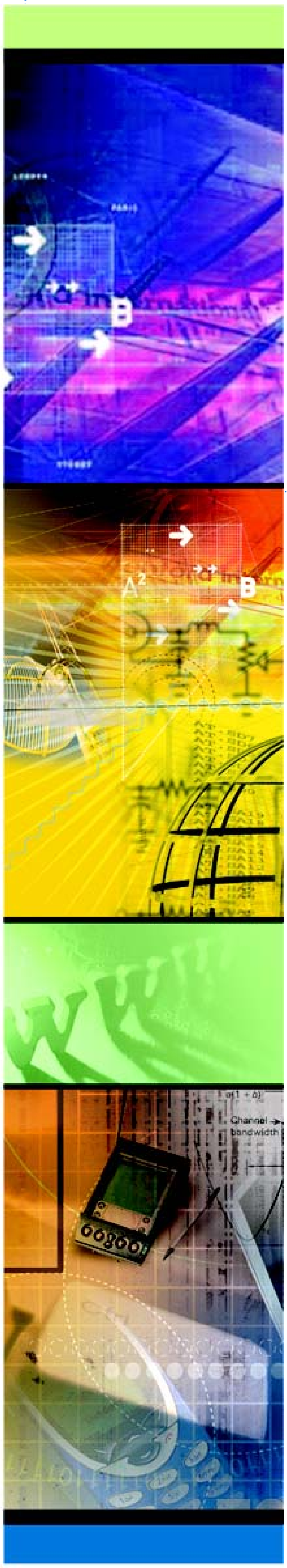
While he spoke, the others took their leave

Put a dot on the "i" and sharpen the point

The gift of speech was denied the poor child

Appendix B:

Mobile-to-Mobile Receiver Overload Analysis



H Block MS overload analysis

Prepared for:
Nextel Communications, Inc.

LCC International, Inc.

the knowledge that powers the network

December 1, 2004

Table of Contents

1 Introduction

The presence of the H-Block is believed to create harmful interference to "millions of existing PCS handsets" [1]. We are going to prove that the likelihood of such interference is extremely low, such that it can't be actually identified in a cellular system. The overload interference will manifest similarly with lack of service coverage [2]. Currently, within the cellular industry, coverage outage figures (probability to have areas without RF coverage) are at best 5% [3], [4]. We prove that the likelihood of overload blocking PCS incumbent CDMA phones by nearby UL transmitting H Block phones is several orders of magnitude smaller.

[1] H Block, Overload test results, August 31, 2004, Nokia

[2] Service Coverage is based on signal strength and refers to the network's ability in achieving signal strength of -104 dBm or better.

[3] Simon Sounders, Antennas and propagation for Wireless Communication Systems, John Willey, 1999

[4] Jean-Frédéric Wagen, Karim Rizk, *Radiowave propagation, building databases, and GIS: anything in common? A radio engineer's viewpoint,* Environment and Planning B: Planning and Design 2003, volume 30, pages 767 ^ 787

2 Overload blocking probability

In the analysis below, we will denote by victims incumbent PCS forward-link connected phones, and by aggressors phones transmitting on the H Block reverse link.
For a conservative analysis, we are going to consider overloading as a non –linear process, such that every victim jammed by H Block RF power levels beyond –22dBm is blocked (out of service). In reality, there are instances when DL power control has enough margin for alleviating blocking by increasing the useful signal level for the victims.
According to the test results performed by Nokia Labs, [1] the minimum blocking power measured over a set of 7 randomly selected phone models amounts to W_{Rxb0}= -22dBm [5] (I_{or}=-100 dBm/Hz, AWGN applied for 1% FER). Direct conversion phones have poor blocking characteristics (-22 dBm to – 8dBm), while the super heterodyne architecture shows blocking characteristics better than–5dBm.
The following scenarios are going to be considered when calculating the blocking probability for incumbent PCS phones,

1. H Block phones operated at maximum W_{Tx0}=23dBm
2. H Block phones operates at W_{Tx1}=33dBm

2.1 Assumptions

The following assumptions are considered for the blocking analysis

- Coordinated scenario; H Block and PCS base station are collocated (Figure 1)
- Macro cell environment with 3 sectors (Figure 1)
  - For micro cell, phones' maximum transmit power usually does not exceed 17 dBm, power level that does not create overload interference
- Very populated towers, having on average 10 incumbent CDMA PCS carriers
- Heavy loaded cell supporting 30 users per carrier, thus leading to 300 incumbent PCS and 30 H Block active subscribers per sector.
- Uniform distribution of subscribers within the cell

Figure 1shows the collocation scenario. Victim and aggressor phones are uniformly distributes within 120-degree sectors. Due to the homogeneous scenario (same radius cells), the analysis is performed in one sector, the results being valid for any arbitrary sector.

[5] Measurements performed by Nextel Communications on four CDMA phones operated on channel 25 (PCS) shows a minimum blocking power of W_{Rxb1}= –12dBm.

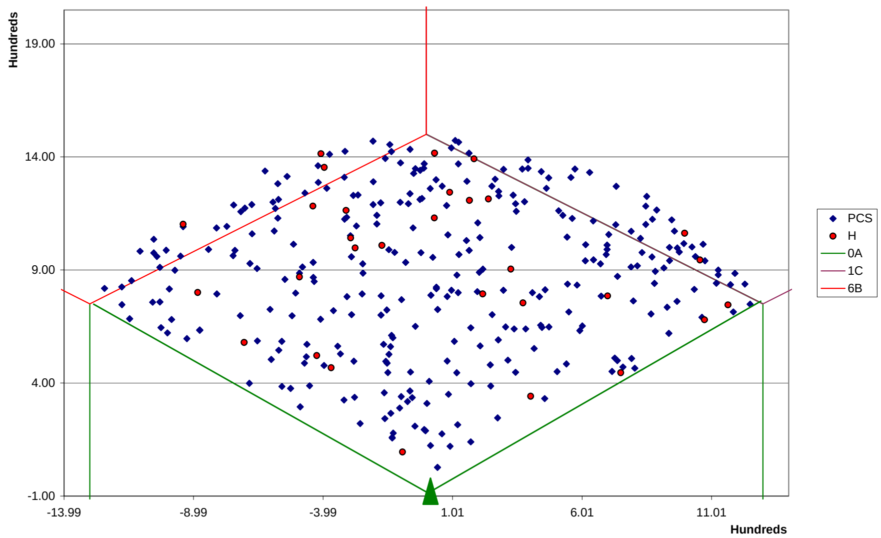


Figure 1 *Collocation scenario with victims (PCS) and aggressors (H)*

2.2 Analysis model

Each victim receiver (PCS DL connected phone) may be blocked if there is at least one aggressor (H Block UL connected phone) within distance d_J, the overload isolation distance. Accordingly, circles around victim receivers describe blocking areas (Figure 2)

$$S_J = \pi \cdot d_J^2 \tag{1}$$

The minimum required isolation (I_{min}) between victims and aggressors (assuming at least one aggressor inside S_J) is calculated from the equation below

$$W_{Tx} - AG_{Tx} - I_{\min} - AG_{Rx} = W_{RxB} \tag{2}$$

where

W_{Tx} Maximum transmit power at aggressor phone PA

W_{RxB} Minimum blocking power for victim phones at antenna connector

$AG_{Tx(Rx)}$ Antenna efficiency for the transmitter or receiver, respectively

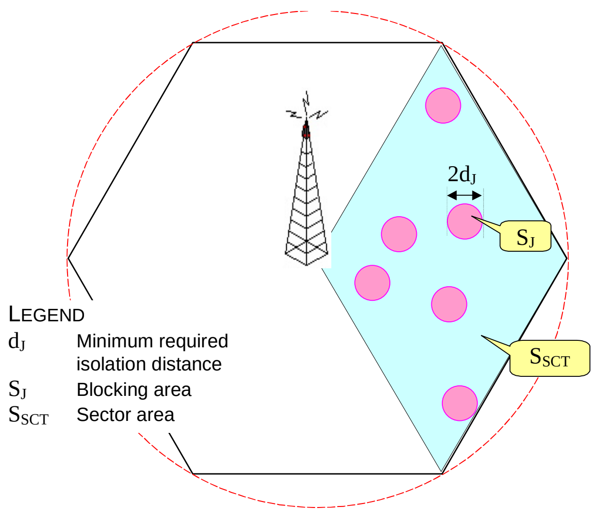


Figure 2 *Sector and blocking areas for randomly distributed victims*

Using the free space model at f=1918.75 MHz, the minimum distance d_J for the required isolation results from

$$I_{\min} = 32.4 + 20 \cdot \log_{10}(f[Mhz]) + 20 \cdot \log_{10}\left(d_J[km]\right) \quad (3)$$

$$d_J[m] = 10^{(I_{\min} - 32.4 - 20 \cdot \log_{10}(f)/20 + 3} \quad (4)$$

The number of PCS connected subscribers within a sector give the number of victims N_V. In the same way, the number of H Block connected phones, give the number of aggressors within the same sector N_A. For a uniform distribution of aggressors, the probability p_{1b} of having one victim within S_J is given by

$$p_{1b} = \frac{S_J}{S_{SCT}} = 3\frac{d_J^2}{R_{cell}^2} \quad (5)$$

where R_{cell} is the cell radius.
For N_A aggressors (H Block UL connected phones), the probability of blocking a victim becomes

$$p_A = N_A p_{1b} \quad (6)$$

The above probability applies for each victim (PCS DL-connected phones) within a given sector. The probability of blocking K-victims out of N_V may be calculated using a Binomial distribution. Accordingly, the average number of blocked victims (N_{VB}) per sector is

$$\mathbf{E}\{N_{VB}\} = N_V\, p_A \quad (7)$$

For the coordinated scenario considered, the total number of victims within a given sector depends on the number of PCS carriers per site and the number of victims per carrier

$$N_V = N_C \cdot N_{V/C}$$

According to [6], the "crude" aggression probability within a sector is defined as the statistical average of the ratio $\mathbf{E}\{N_{VB}/N_V\}$

$$P_{A,\sec tor}^c = \mathbf{E}\{\frac{N_{VB}}{N_V}\} = p_A \quad (8)$$

The above aggression probability considers that all aggressors are transmitting at full power all the time and at any location within the sector. According to [7] (Table 2.1.2-2), phones exercising voice services have a probability of exceeding 22dBm transmit power of 1.81%. Thus, the adjusted aggression probability within a sector becomes

$$P_{A,\sec tor} = 0.0181 \cdot P_{A,\sec tor}^c \quad (9)$$

For probabilities lower than 1.81%, the adjusted aggression probability would become smaller. From this perspective, our analysis again proves to be conservative, including figures for suburban topography only, e.g. for urban topography the probability of exceeding 22 dBm is only 0.19%. Aggressors transmitting less than 22 dBm (disregarding voice activity averaging) will never overload victims within distance d_J.
Due to the conservative non-linear model selected, every aggressed victim will be blocked. Thus, the blocking probability within the cell equals $P_{A,\sec tor}$

$$P_{B,\sec tor} = P_{A,\sec tor} \quad (10)$$

[6] N. Cotanis, Designing guard bands for minimal performance degradation, Global Mobile Congress, Shanghai, 11-13 October 2004

[7] CDG, System Performance Tests, Revision 3.0,April 9, 2003

3 Results

3.1 Low power aggressors

The assumptions for this scenario are presented in Table 1. The maximum transmit power is W_{Tx0}=23 dBm. For each sector, we consider 10 CDMA carriers (N_C) with 30 active victims per carrier ($N_{V/C}$), resulting to 300 victims per sector. There is one H Block RF carrier per cell with 30 aggressors (N_A).

Table 1 Assumptions for 23dBm scenario

f	MHz	1918.75
Tx power	dBm	23
AE_Tx	dB	-3
AE_Rx	dB	-3
Block power	dBm	-22
PL model		FSL

N_A		30
$N_{V/C}$		30
N_C		10
min Rcell	m	1000
max Rcell	m	5000

Using (2) and (3), the required isolation is derived in (Table 2).

Table 2 Required isolation figures

Isolation	dB	39
Isolation distance	M	1.115

The blocking probability is represented in Figure 3. The larger the cell (sector) radius, the smaller the blocking probability is. Blocking probabilities result to be extremely low in comparison with industry standard coverage outage of 5% for sub-urban areas. For rural areas, where cell radii larger, the target coverage outage may go up to 10%.

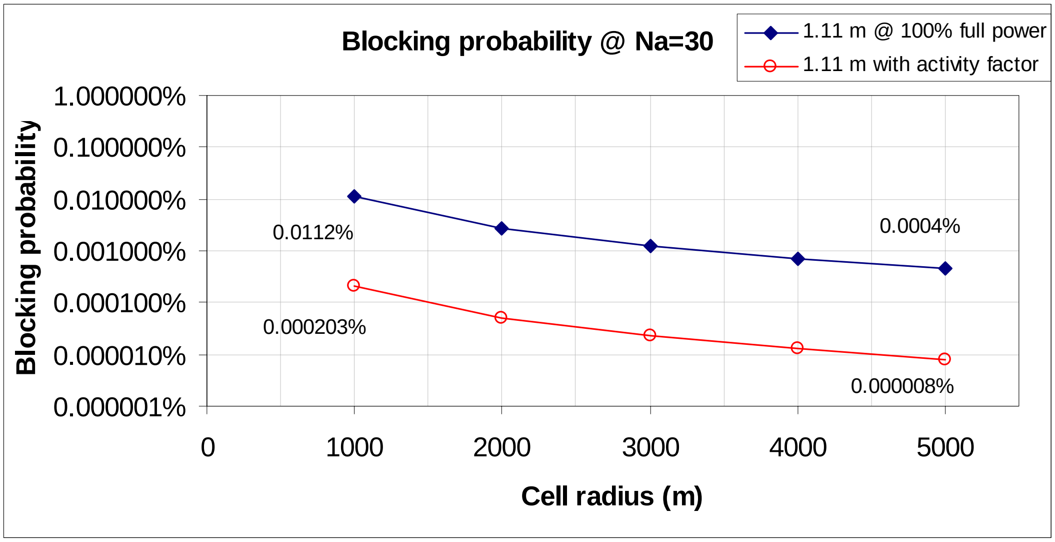


Figure 3 ***Blocking probability***

The blocking probability in a real system is expected to be significantly low because of the conservative assumptions made throughout the analysis.

3.2 High power aggressors

The assumptions for this scenario are presented in Table 3. The maximum transmit power is relaxed to W_{Tx1}=33 dBm

Table 3 *Assumptions for second scenario*

f	MHz	1918.5
Tx power	dBm	33
AE_Tx	dB	-3
AE_Rx	dB	-3
Block power	dBm	-22
PL model		FSL

N_A		30
$N_{V/C}$		30
N_C		10
min Rcell	m	1000
max Rcell	m	5000

The required isolation is going up to 49dB, increasing the isolation distance to 3.53m (Table 4). The results will prove, that even for the relaxed scenario, blocking instances will be concealed by the existent coverage outage.

Table 4 *Required isolation figures for second scenario*

Isolation	dB	49
Isolation distance	m	3.526

The blocking probability is represented in Figure 4. Again, blocking probabilities are extremely low (0.002%) in comparison with industry standard coverage outage of 5% for sub-urban areas.

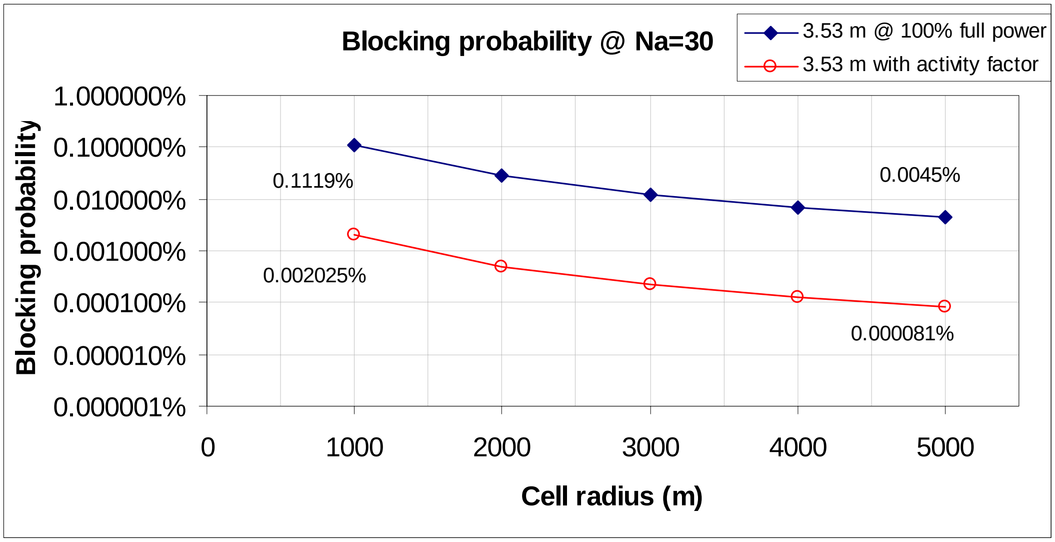


Figure 4 *Blocking probability*

4 Conclusions

The overload interference resulting from H Block presence creates extremely low service degradation for incumbent PCS phones, such that overloading can't be actually identified from the total reported outage in the system. Using a very conservative model, the analysis proves that the overload likelihood is several orders of magnitude smaller than the initial service outage in the PCS band, before H Block deployment. The analysis is based on several very conservative assumptions, as listed below

- Full power aggressors everywhere within the sector
- Co-located sites
- Heavy traffic, 30 users per carrier
- Heavy loaded towers, 10 incumbent PCS carriers, leading to 300 PCS users per sector
- No DL power control for alleviating some overloading instances
- No handoff gain for victims
- Transmit power distribution for suburban sites only

Considering all of the above, the likelihood of overload interference in real life incumbent PCS systems will be significantly lower than the reported results.

Appendix C:

H Block Performance Test Report

Wireless Test Systems, Inc.
Nextel H Block Interference Testing
Test Report

Document Control Number 2046
Revision 1.1
December 07, 2004

A2LA Certificate 1935.01

CTIA Authorized Test Lab
LAB CODE 20020222-00

Wireless Test Systems, Inc.
16870 W. Bernardo Drive
Suite 250
San Diego, CA. 92127

Revision List

Revision	Date	Issuing Authority	Summary of Changes
1.0	12/02/04	BMD	Initial Release
1.1	12/07/04	BMD	Deleted Section 5.5 OOBE.

Approval

Testing Manager: Nathan Gieselman

Signature: ____________________

Date: 2 December 2004

Lab Manager: Michael Spitzer

Signature: ____________________

Date: 2 December 2004

Table of Contents

Table of Figures

1 References

The following references are applicable to this document:

1. Recommended Minimum Performance Standards for cdma2000 Spread Spectrum Mobile Stations. TIA-98-E, February 2003, Telecommunications Industry Association
2. Nokia Letter to FCC dated September 7, 2004 RE: Ex Parte Letter

2 Introduction

The purpose of this document is to record the testing performed at Nextel's request for H-block interference. In this document you will find a description of the testing performed, a description of the test equipment, and the test results recorded.

2.1 Test Execution Dates

November 1, 2004 through December 2, 2004

3 Environment

3.1 Temperature

The test samples were tested at room temperature.

3.2 Test Channels

The following table list the primary channels tested:

Standard	Channels
TIA/EIA-98-E Band Class 1	25, 600, 1175

4 Test Equipment

4.1 Test Hardware

The following table lists the test equipment used during the conduct of the certification testing:

Equipment	Manuf.	Serial #	Calibration Date	Due Date	Cal. Cycle
E5515C Momentum Box	Agilent	GB41070188	3/18/2003	**3/18/2005**	24 Months
E4418B Power Meter	Agilent	GB41299041	7/7/2004	**7/7/2005**	12 Months
E9301A Power Sensor	Agilent	US39210274	7/8/2004	**7/8/2005**	12 Months
E4407B Spec. Analyzer	Agilent	US39160278	9/29/2004	**9/29/2005**	12 Months
E4436B Signal Generator	Agilent	US39260795	8/25/2003	**8/25/2005**	24 Months

5 Test Results

5.1 H Block CW Interferer

5.1.1 Test Configuration for H Block CW Interferer

The figure below shows the test equipment configuration used for testing.

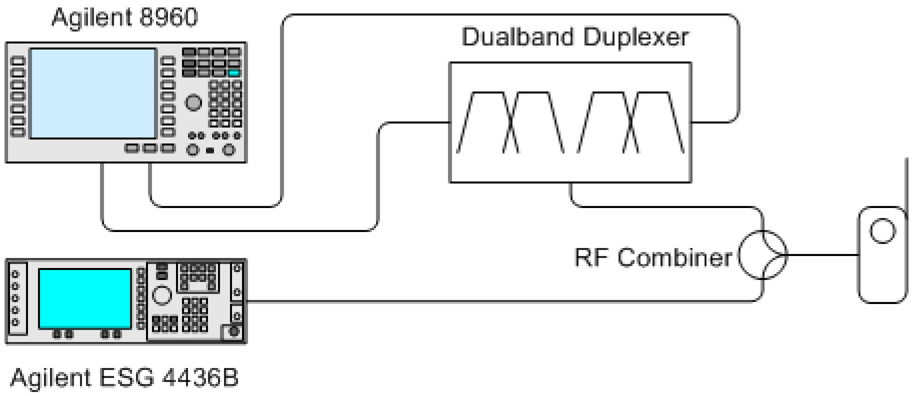


Figure 5.1.1 H Block CW Interferer Equipment Configuration

5.1.2 Test Approach

The test approach to determine the affect of an H block CW signal on the mobile station receiver performance when on A, B and C block was to establish a CDMA call using a service option 2 loopback connection then to monitor the mobile stations performance utilizing the Frame Error Rate (FER) measurement while inserting a CW signal in the H block. The CW signal was set to 1918.75 MHz.

5.1.3 Test Steps

1) Calibrate all applicable path losses. The path losses are: 8960 to mobile station (forward channel), mobile station to 8960 (reverse channel) and signal generator to mobile station. Insert the path losses into applicable screens on the 8960 and ESG4436.
2) Configure the Agilent 8960 as follows:
    a. Band US PCS (Band Class 1)
    b. Channel 25
    c. Radio configuration 1, service option 2 loopback
    d. Traffic channel = -15.6 dBm
3) Page the mobile station and establish the traffic channel.
4) Set the 8960 sector power to -101 dBm/1.23 MHz.
5) Configure the signal generator frequency to 1918.75 MHz and modulation off. Set the signal amplitude to -30 dBm and turn on the RF power.
6) On the 8960, go to the FER screen and configure the FER measurement as follows:
    a. Maximum frames = 1000
    b. Confidence = Off
    c. Single execution
7) Increase the signal generator amplitude in 1 dB steps while monitoring the FER. Once frame errors begin to occur, begin to take 3 measurements at each interferer amplitude. Average the 3 measurements and record the average.

8) Repeat step 7 until the FER reaches 100%. In the cases where the FER exceeds 60%, turn off the call drop timer on the 8960 in order to maintain the connection.
9) Repeat the procedure while configuring the 8960 for channels 600 and 1175.

5.1.4 Test Results

The following graph details the test results for 8 mobile stations tested. There were 4 representative models selected with 2 samples of each model. FER versus signal generator amplitude is plotted.

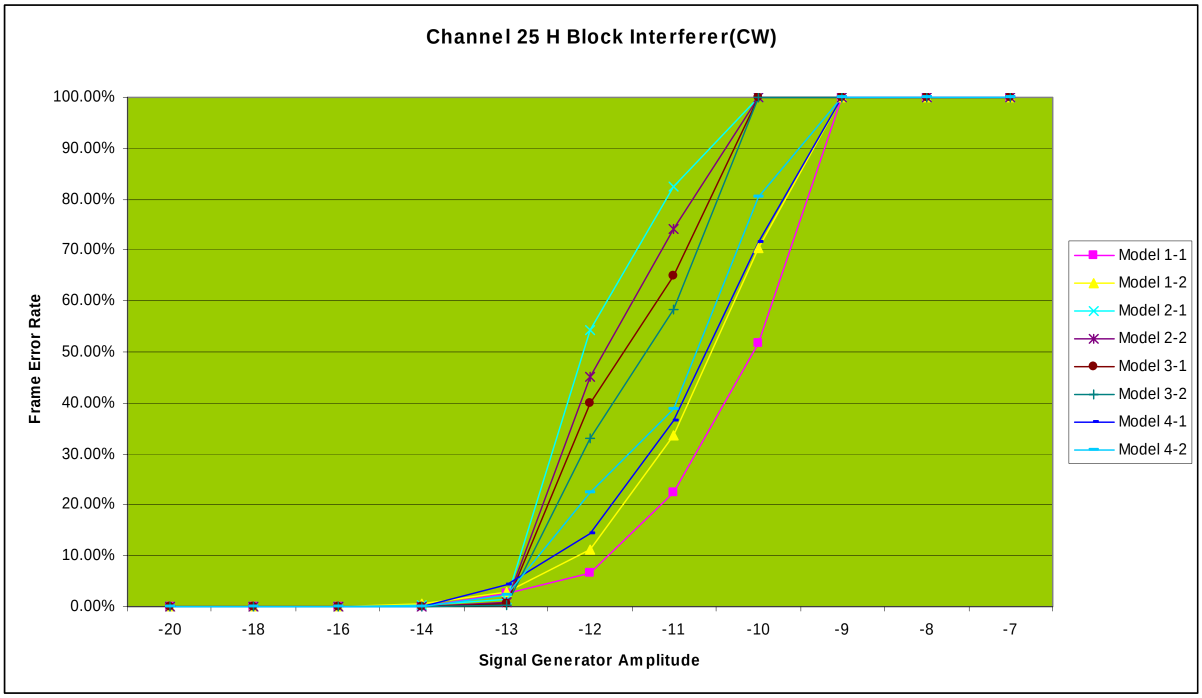


Figure 5.1.4-1 Channel 25 H Block Interferer(CW)

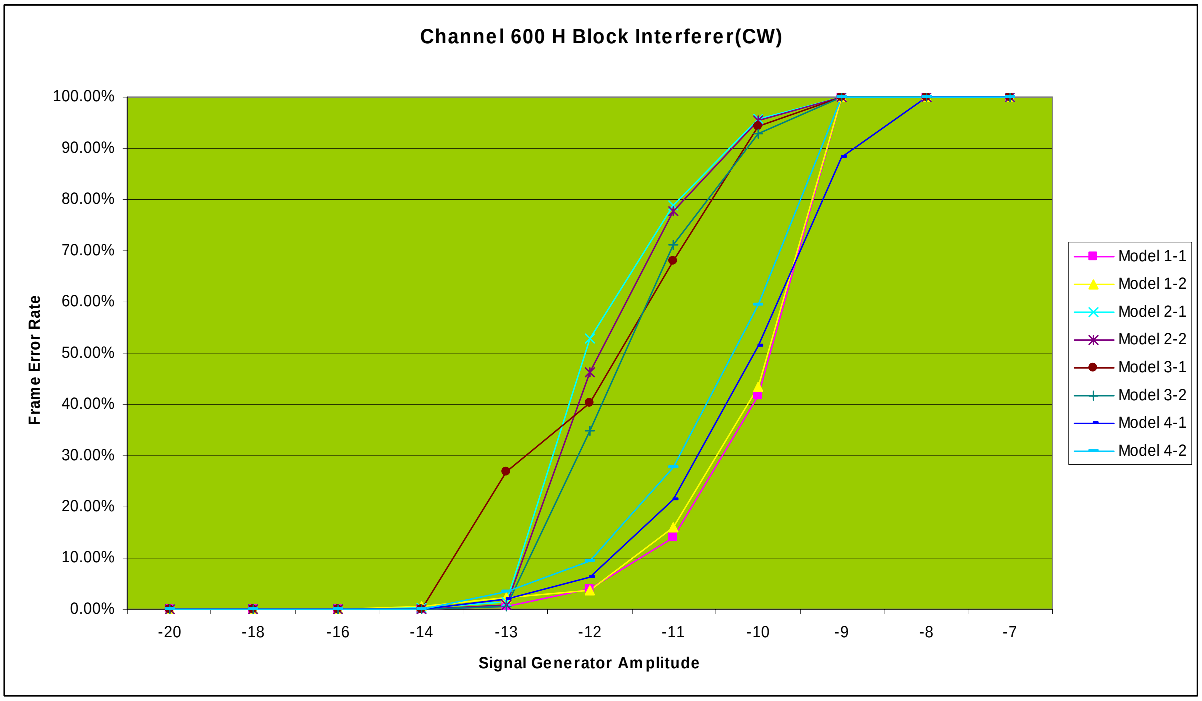


Figure5.1.4-2 Channel 600 H Block Interferer(CW)

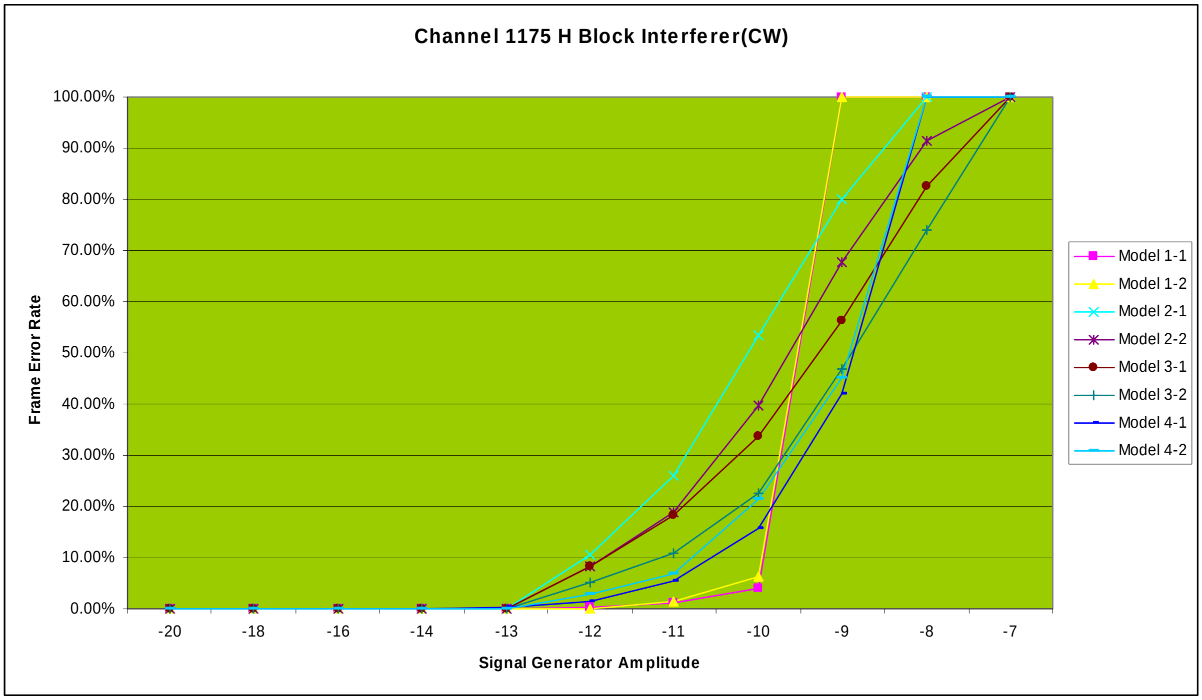


Figure 5.1.4-3 Channel 1175 H Block Interferer(CW)

5.2 H Block CDMA Interferer

5.2.1 Test Configuration for H Block CDMA Interferer

The figure below shows the test equipment configuration used for testing.

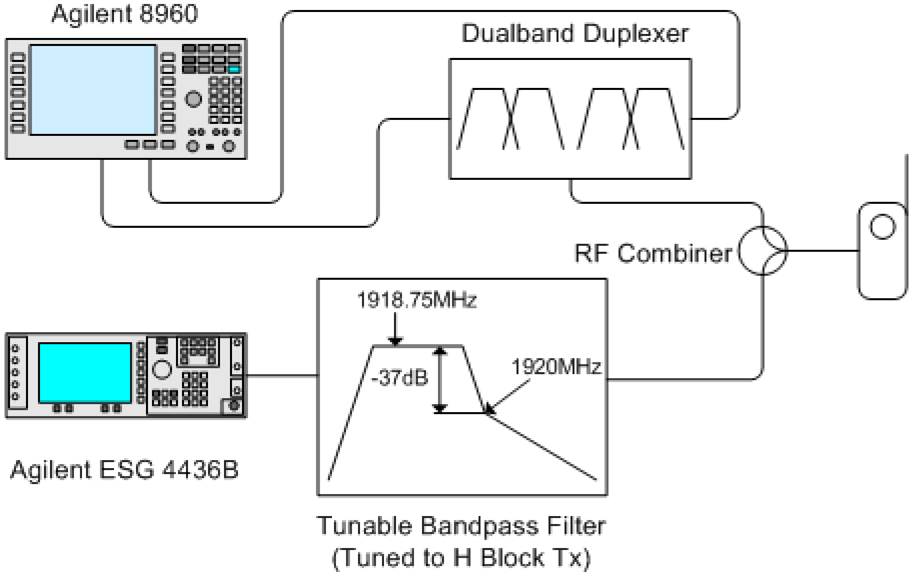


Figure 5.2.1 H Block CDMA Interferer Equipment Configuration

5.2.2 Test Approach

The test approach to determine the affect of an H block CDMA signal on the mobile station receiver performance when on A, B and C block was to establish a CDMA call using a service option 2 loopback connection then to monitor the mobile stations performance utilizing the Frame Error Rate (FER) measurement while inserting a modulated CDMA signal in the H Block. The CDMA signal was set to 1918.75 MHz.

5.2.3 Test Steps

1) Calibrate all applicable path losses. The path losses are: 8960 to mobile station (forward channel), mobile station to 8960 (reverse channel) and signal generator to mobile station. Insert the path losses into applicable screens on the 8960 and ESG4436.
2) Configure the Agilent 8960 as follows:
    a. Band US PCS (Band Class 1)
    b. Radio configuration 1, service option 2 loopback
    c. Traffic channel = -15.6 dBm
3) Page the mobile station and establish the traffic channel.
4) Set the 8960 sector power to -101 dBm/1.23 MHz.
5) Configure the signal generator frequency to 1918.75 MHz and modulate to CDMA waveform. Set the signal amplitude to -30 dBm and turn on the RF power.
6) On the 8960, go to the FER screen and configure the FER measurement as follows:
    a. Maximum frames = 1000
    b. Confidence = Off
    c. Single execution

7) Increase the signal generator amplitude in 1 dB steps while monitoring the FER. Once frame errors begin to occur, begin to take 3 measurements at each interferer amplitude. Average the 3 measurements and record the average.
8) Repeat step 7 until the FER reaches 100%. In the cases where the FER exceeds 60%, turn off the call drop timer on the 8960 in order to maintain the connection.
9) Repeat the procedure while configuring the 8960 for channels 600 and 1175.

5.2.4 Test Results

The following graph details the test results for 8 mobile stations tested.

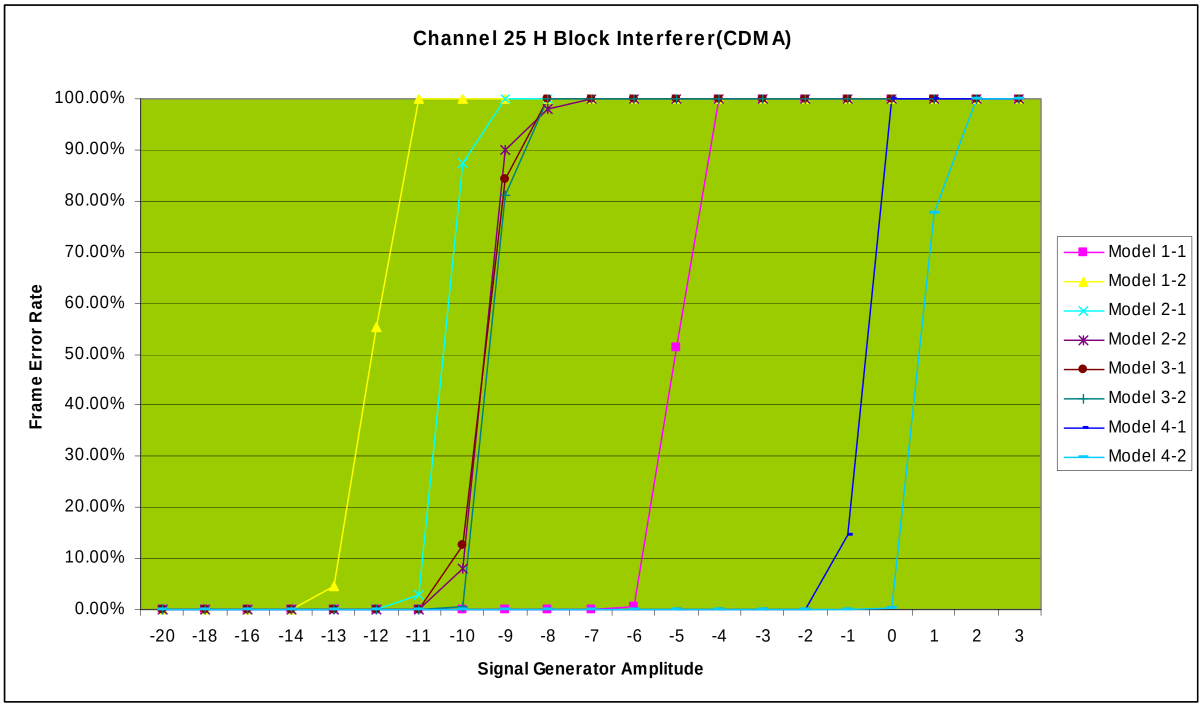


Figure 5.2.4-1 Channel 25 H Block Interferer(CDMA)

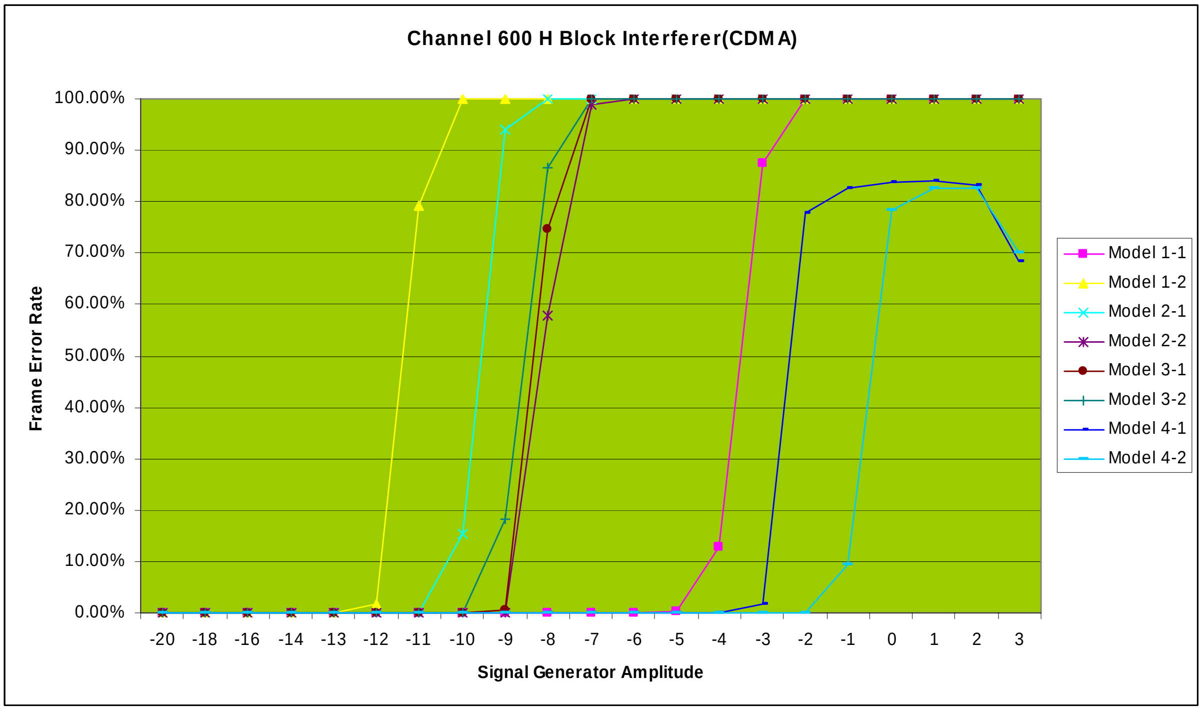


Figure 5.2.4-2 Channel 600 H Block Interferer(CDMA)

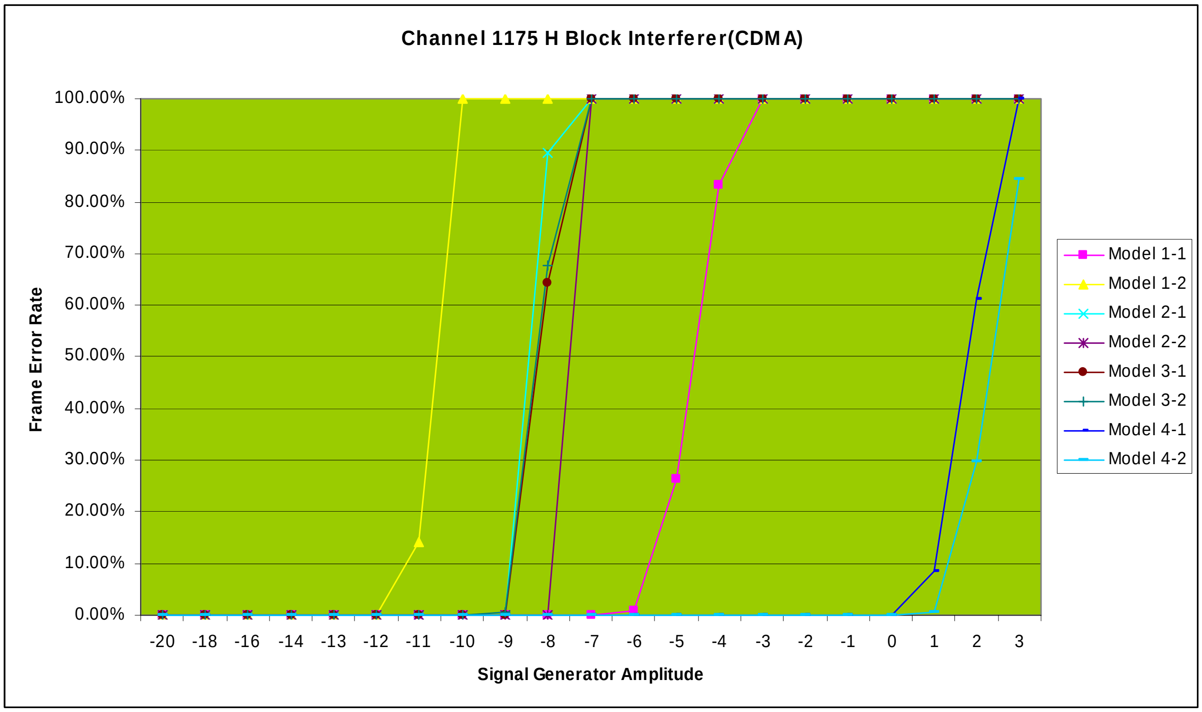


Figure 5.2.4-3 Channel 1175 H Block Interferer(CDMA)

5.3 PCS In-Band CW Interferer

5.3.1 Test Configuration for PCS In-Band CW Interferer

The test equipment configuration from figure 5.1.1 was used for testing.

5.3.2 Test Approach

The test approach to determine the affect of an in-band CW signal on the mobile station receiver performance when on an A block channel was to establish a CDMA call using a service option 2 loopback connection then to monitor the mobile stations performance utilizing the Frame Error Rate (FER) measurement while inserting a CW signal on B and C Block channels. The CW signal was set to 1960 MHz and 1988.75 MHz.

5.3.3 Test Steps

1) Calibrate all applicable path losses. The path losses are: 8960 to mobile station (forward channel), mobile station to 8960 (reverse channel) and signal generator to mobile station. Insert the path losses into applicable screens on the 8960 and ESG4436.
2) Configure the Agilent 8960 as follows:
    a. Band US PCS (Band Class 1)
    b. Channel 25
    c. Radio configuration 1, service option 2 loopback
    d. Traffic channel = -15.6 dBm
3) Page the mobile station and establish the traffic channel.
4) Set the 8960 sector power to -101 dBm/1.23 MHz.
5) Configure the signal generator frequency to 1960 MHz and modulation off. Set the signal amplitude to -30 dBm and turn on the RF power.
6) On the 8960, go to the FER screen and configure the FER measurement as follows:
    a. Maximum frames = 1000
    b. Confidence = Off
    c. Single execution
7) Increase the signal generator amplitude in 1 dB steps while monitoring the FER. Once frame errors begin to occur, begin to take 3 measurements at each interferer amplitude. Average the 3 measurements and record the average.
8) Repeat step 7 until the FER reaches 100%. In the cases where the FER exceeds 60%, turn off the call drop timer on the 8960 in order to maintain the connection.
9) Repeat the procedure for a signal generator frequency of 1988.75 MHz.

5.3.4 Test Results

The following graph details the test results for 8 mobile stations tested.

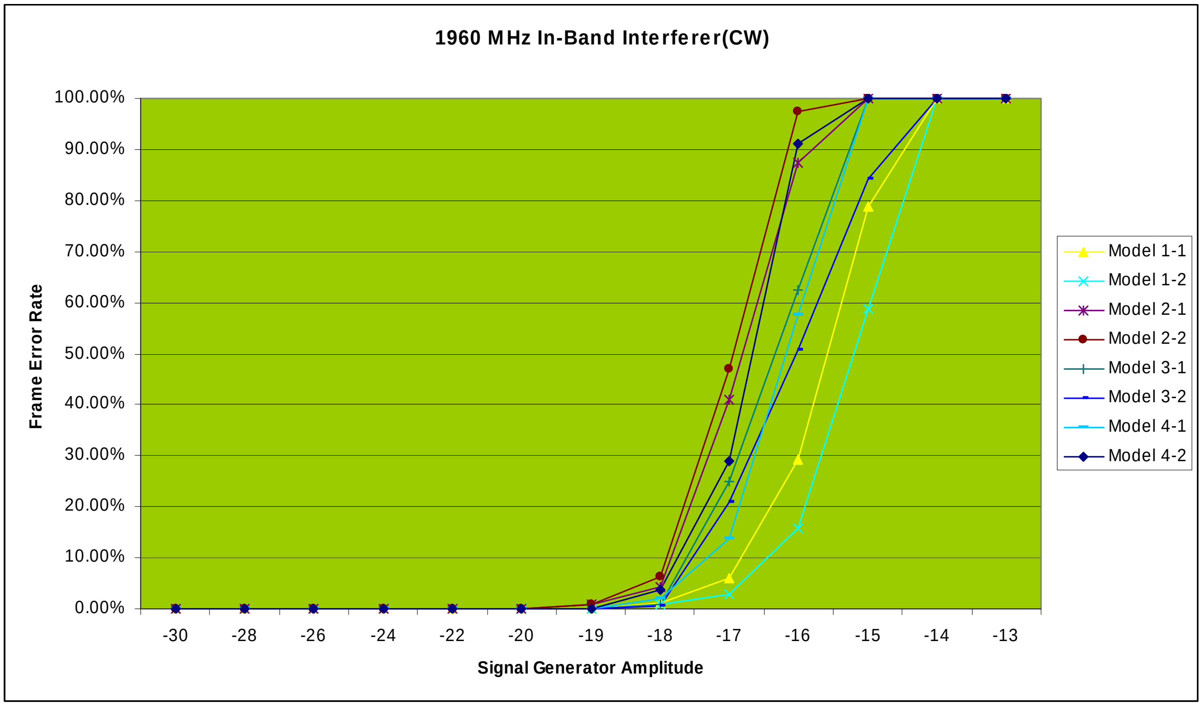


Figure 5.3.4-1 1960 MHz In-Band Interferer(CW)

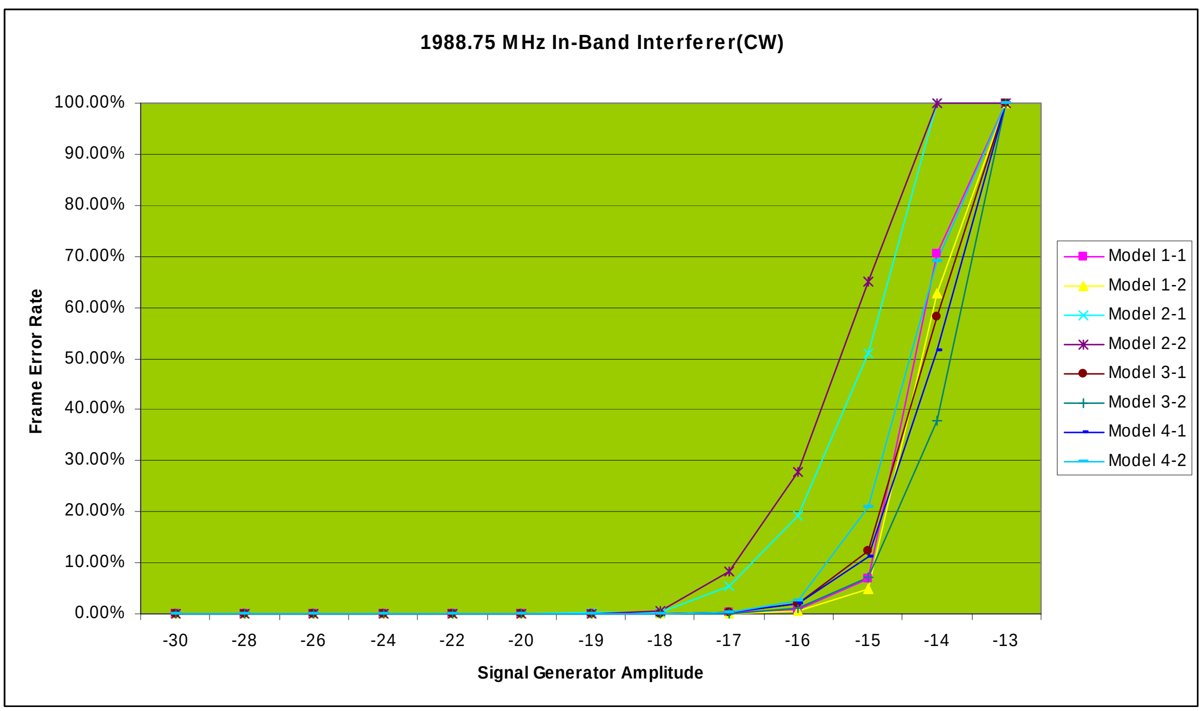


Figure 5.3.4-2 1988.75 MHz In-Band Interferer(CW)

5.4 PCS In-Band CDMA Interferer

5.4.1 Test Configuration for PCS In-Band CDMA Interferer

The test equipment configuration from figure 5.1.1 was used for testing.

5.4.2 Test Approach

The test approach to determine the affect of an in-band CDMA signal on the mobile station receiver performance when on an A block channel was to establish a CDMA call using a service option 2 loopback connection then to monitor the mobile stations performance utilizing the Frame Error Rate (FER) measurement while inserting a modulated CDMA signal in the B and C block. The CDMA signal was set to 1960 MHz and 1988.75 MHz.

5.4.3 Test Steps

1) Calibrate all applicable path losses. The path losses are: 8960 to mobile station (forward channel), mobile station to 8960 (reverse channel) and signal generator to mobile station. Insert the path losses into applicable screens on the 8960 and ESG4436.
2) Configure the Agilent 8960 as follows:
    a. Band US PCS (Band Class 1)
    b. Channel 25
    c. Radio configuration 1, service option 2 loopback
    d. Traffic channel = -15.6 dBm
3) Page the mobile station and establish the traffic channel.
4) Set the 8960 sector power to -101 dBm/1.23 MHz.
5) Configure the signal generator frequency to 1960 MHz and modulate to CDMA waveform. Set the signal amplitude to -30 dBm and turn on the RF power.
6) On the 8960, go to the FER screen and configure the FER measurement as follows:
    a. Maximum frames = 1000
    b. Confidence = Off
    c. Single execution
7) Increase the signal generator amplitude in 1 dB steps while monitoring the FER. Once frame errors begin to occur, begin to take 3 measurements at each interferer amplitude. Average the 3 measurements and record the average.
8) Repeat step 7 until the FER reaches 100%. In the cases where the FER exceeds 60%, turn off the call drop timer on the 8960 in order to maintain the connection.
9) Repeat the procedure for a signal generator frequency of 1988.75 MHz.

5.4.4 Test Results

The following graph details the test results for 8 mobile stations tested.

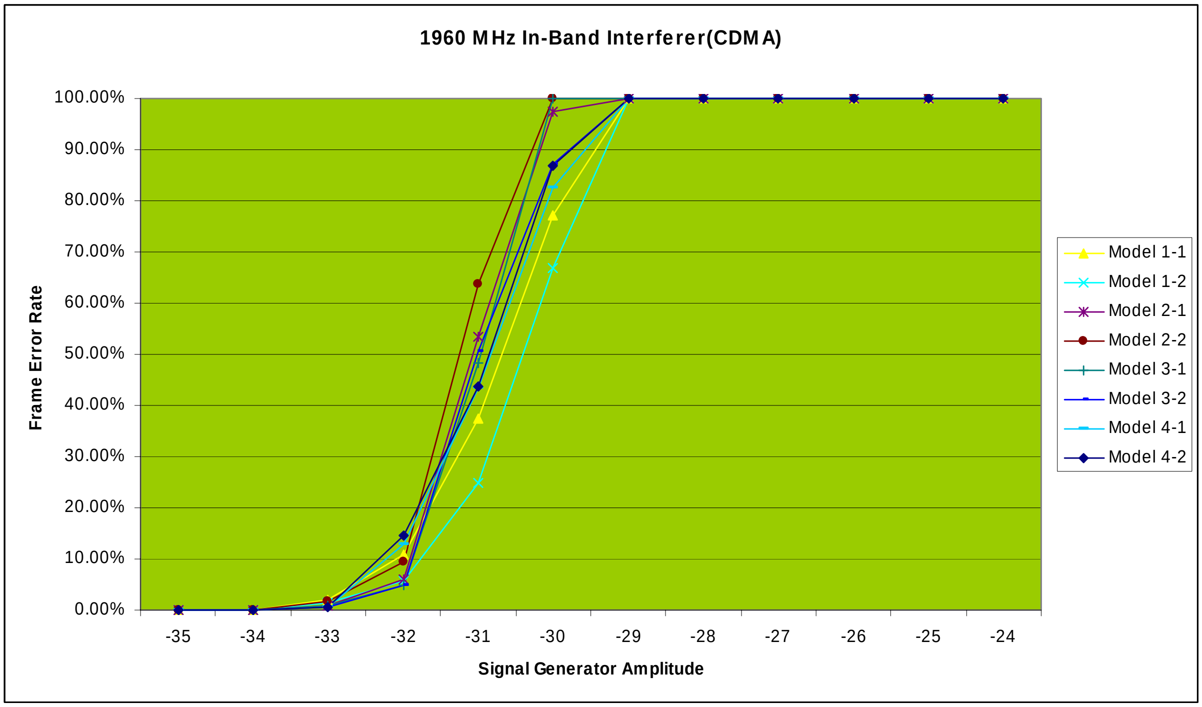


Figure 5.4.4-1 1960 MHz In-Band Interferer(CDMA)

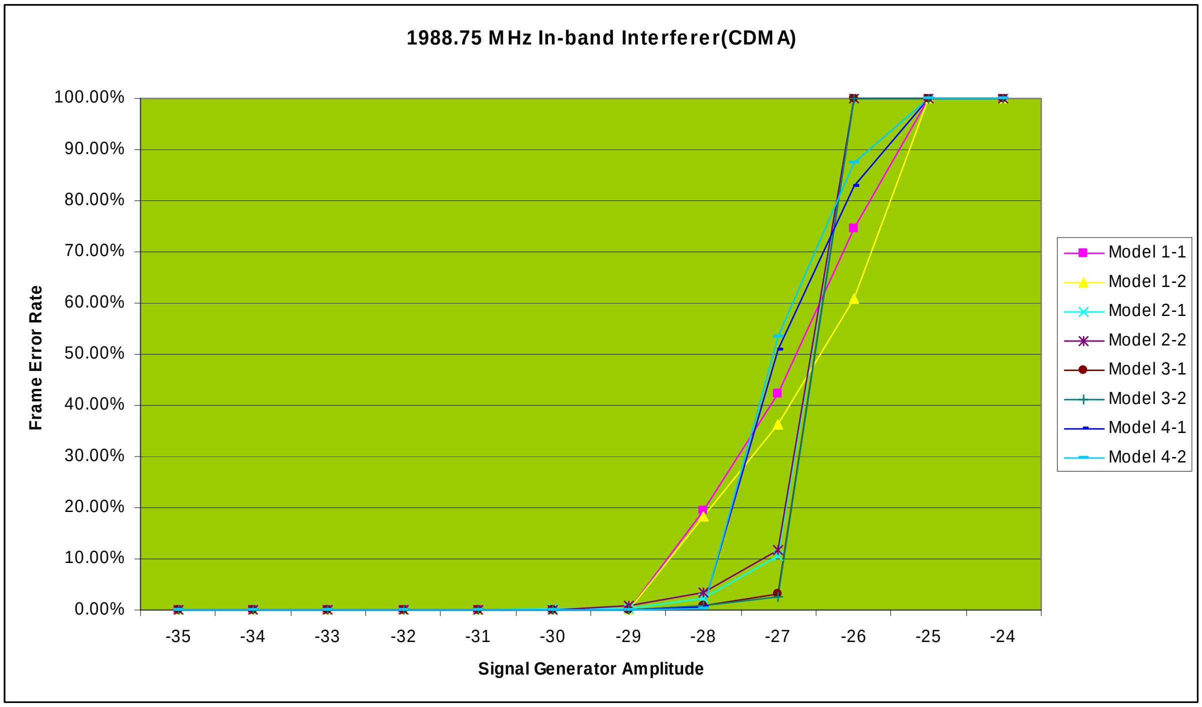


Figure 5.4.4-2 1988.75 MHz In-Band Interferer(CDMA)

End of Document

Appendix D:

MSS Adjacent-Band Interference Analysis

PCS – MSS Adjacent Band Interference Analysis

Provided to

Nextel

Provided by

COMSEARCH®
An Andrew Company

Comsearch

November 19, 2004

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Executive Summary

Comsearch has prepared a report to investigate the interference potential between terrestrial PCS services (PCS) and Mobile Satellite Service (MSS) operating in adjacent bands at 2 GHz. The study is focused on the interference involving PCS base stations transmitting between 1995-2000 MHz and MSS systems operating between 2000-2020 MHz. The 2000-2020 MHz band is a User Link uplink band, meaning user terminal terminals, typically mobile handsets, uplink to the MSS satellites. The 1995-2000 MHz band, also known as the PCS “H” Block, would be used as a PCS downlink band; where the base stations transmit to mobile terminals. The analysis in this report involves interference from PCS base stations into space-based satellite receivers. There are two types of potential interference: the first is out of band emissions (OOBE) or determining the interference signal levels from the PCS transmissions in the band between 2000-2020 MHz. The second is satellite receiver overload or determining if the aggregated PCS signal levels will drive the satellite low noise amplifiers into saturation. Both of these analyses have been performed and the results indicate that proper filtering, frequency separation, and adequate front end design of the satellite receivers will be necessary to mitigate out of band emission interference and receiver overload interference.

Table of Contents

1. Introduction

This study examines the usage of the “H” block spectrum between 1995-2000 MHz for use by PCS terrestrial systems. Specifically, the use of a wide or narrowband CDMA system and the potential for interference into adjacent Mobile Satellite System (MSS) services is examined.

The Mobile Satellite Service (MSS) band adjacent to the H block at 2000-2020 MHz is a is used by MSS as a user link in the earth-to-space direction, i.e. mobile handsets transmitting to the spacecraft receivers. Recently, the FCC has recently granted MSS licensees with the ability to supplement their satellite service with an Ancillary Terrestrial Component (ATC), or a terrestrial underbuild to improve coverage to areas difficult to reach by satellite such as urban canyons and inside of buildings. Interference to the space based receivers is the main area of study in this report.

Two types interference have been examined, they are:

1. Out of Band Emissions (OOBE) – Interference from emissions outside of the H block in the MSS spectrum.
2. Overload - Interference into the MSS receivers which may not have the input amplifier selectivity to reduce the out-of-band PCS signals sufficiently to preclude over-driving of the receive amplifier, resulting in signal suppression of the wanted carriers (clipping), an increase in the noise floor (reduction in carrier C/N).

Incorporating out-of-band filtering on the PCS base station transmitters will lower the out-of-band emissions. Filtering at levels in excess of what is required by the FCC will mitigate OOBE levels. The OOBE levels should not cause any interference to the space or terrestrial receivers. Details are included in this analysis. The receive amplifier overload is the main issue. Providing sufficient filtering and dynamic range at the satellite is required to ensure non-interference between the services.

2. PCS and MSS Operations Scenarios

Several scenarios have been examined to determine the level of expected interference and the best course of action. These involve the number and channel spacing of the PCS carriers. Typically, a five (5) MHz band segment would contain three narrowband CDMA2000 carriers, operating in 1.25 MHz bandwidths or one wideband W-CDMA carrier of 3.87 MHz. For this analysis CDMA2000 technology has been used as an example as the transmission characteristics are well known and the technologies with similar transmission characteristics are expected to produce similar results.

Figure 1 below outlines the proposed spectrum assignment for the terrestrial PCS network and the MSS component. Figure 2 shows the interference coupling modes with an overview of the communications architecture for both systems.

The interference coupling modes consist of interference from a base station sidelobe into the satellite, indirect scattering or reflected energy from the base station into the satellite, and main beam or near-main beam coupling between the base station and nGSO satellites on the horizon. Theses modes are summarized in Figure 4 below.

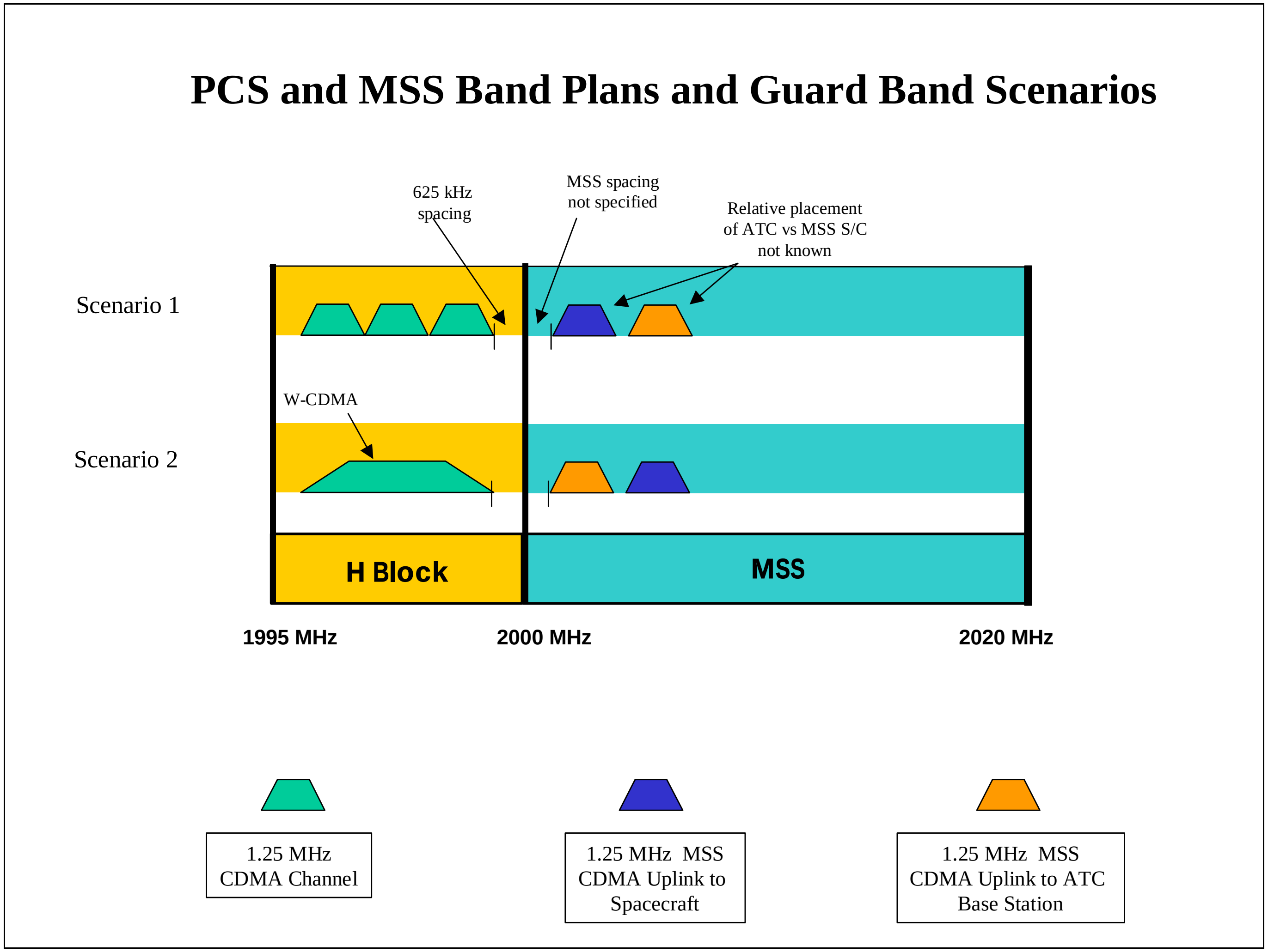
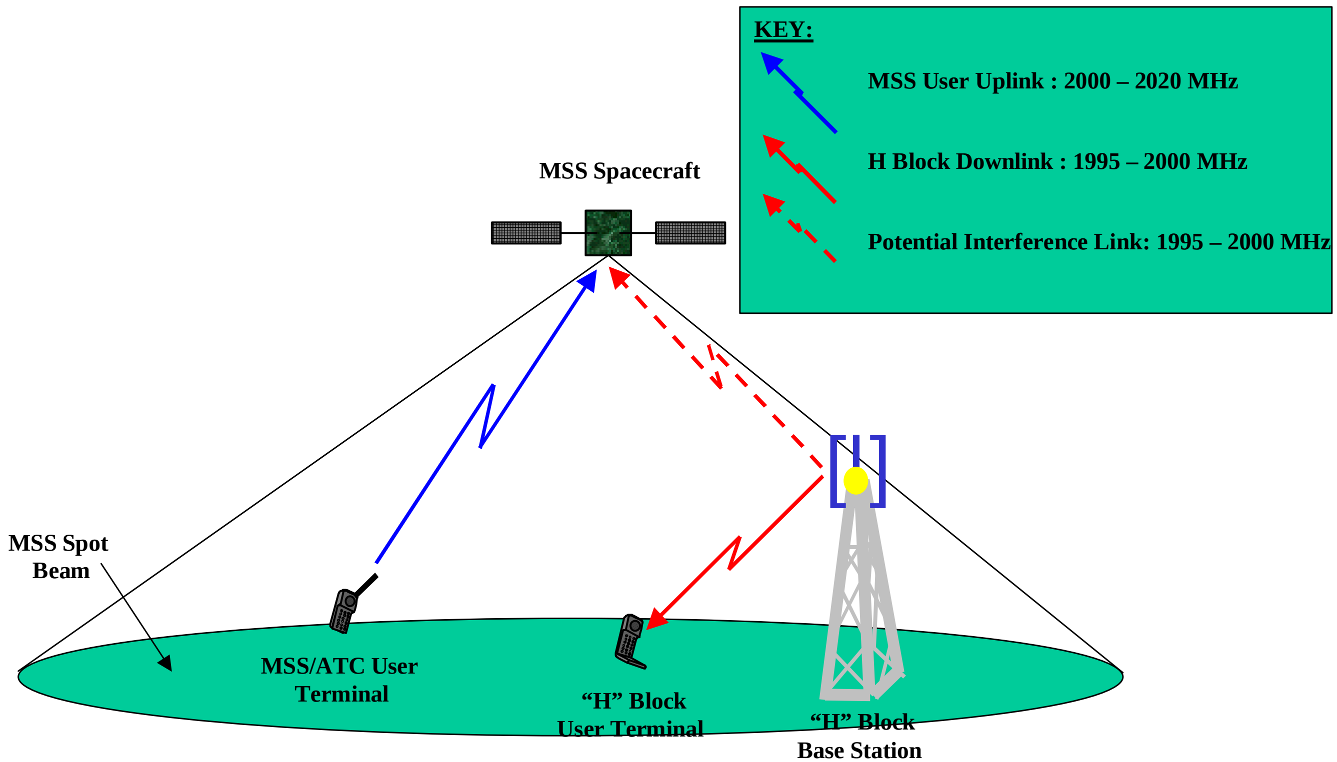


Figure 1 – Nextel Terrestrial H Block band plan and adjacent MSS band plan



Scenario 1 - **MSS User terminal uplinks a signal in the 2000-2020 MHz band to the spacecraft. The Nextel “H” block base station will transmit to the user terminal in the 1995-2000 MHz band. Potential interference exists from the Nextel base station into the MSS spacecraft receiver. Note MSS satellite will use multiple spot beams.**

Figure 2 – Adjacent band sharing between PCS and MSS.

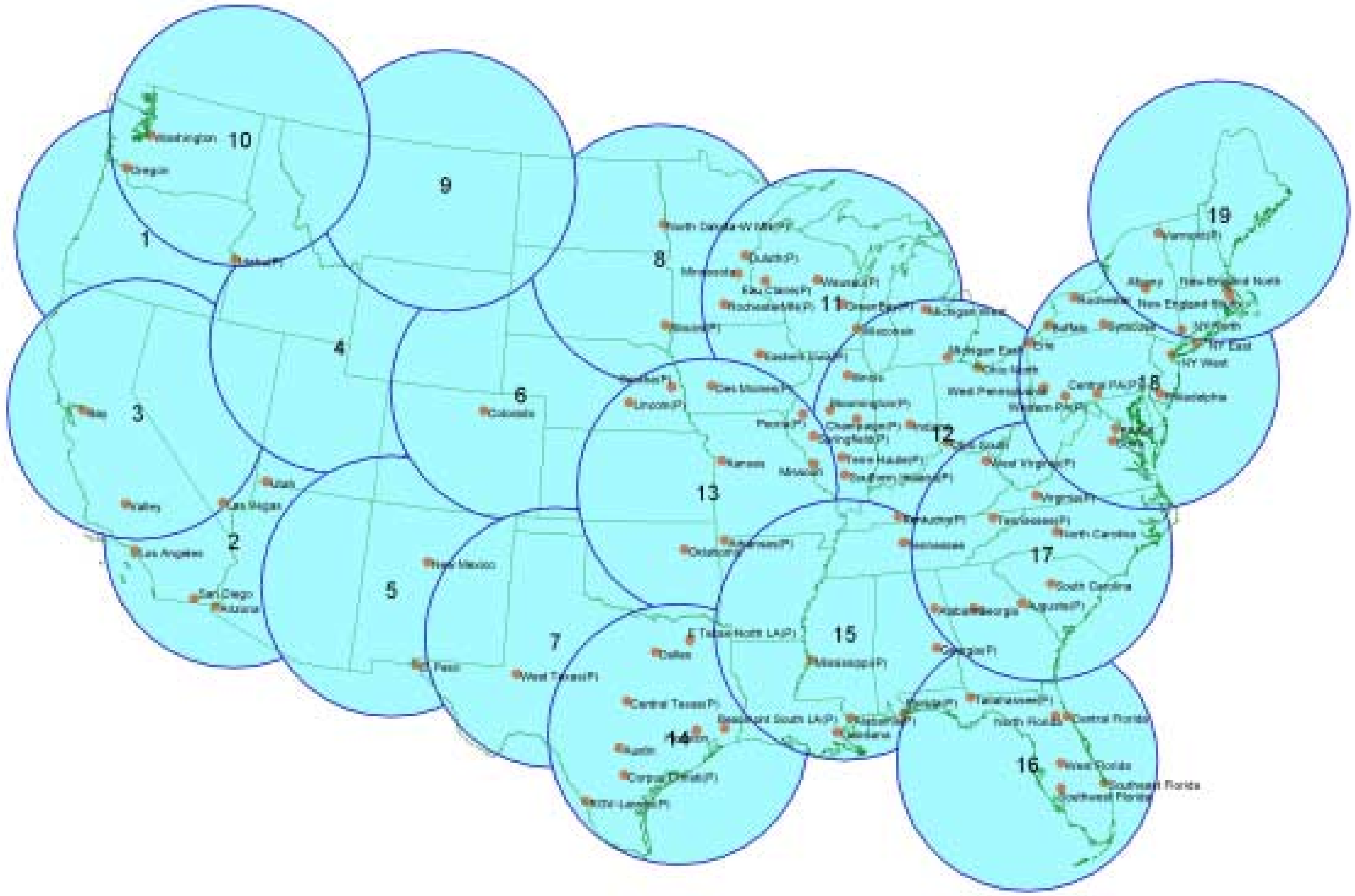
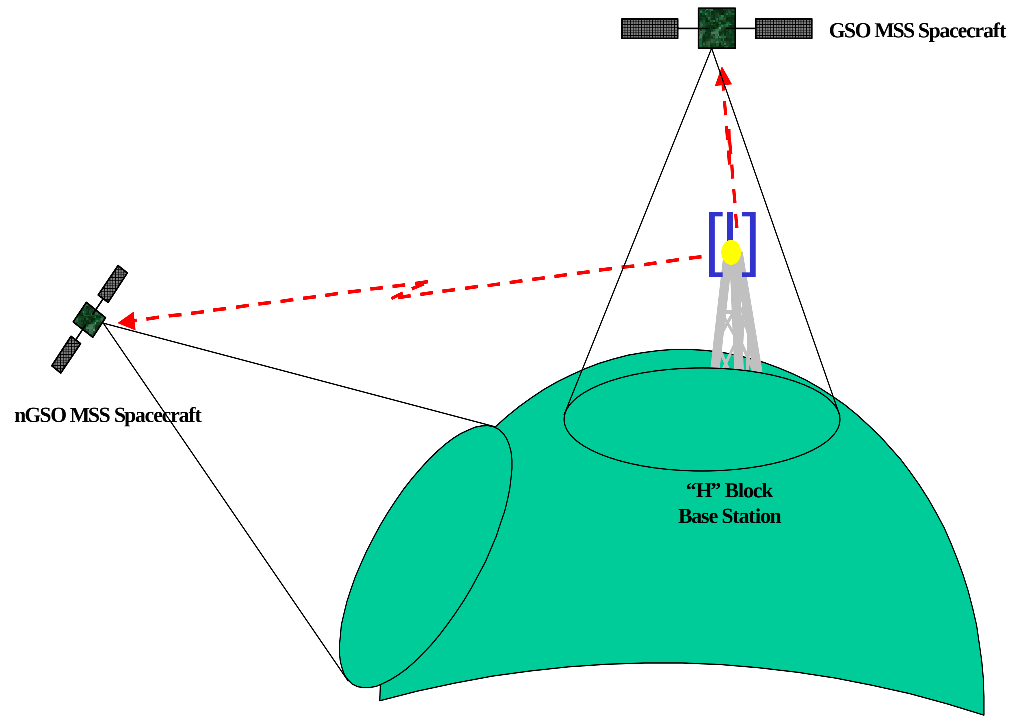


Figure 3 –Terrestrial Base Stations Represented by market areas deployed within 300-mile contours

Table 1 – Number of Base Stations per 300-Mile Contour

Cell #	Number of Base Stations Per Cell
1	629
2	1995
3	1174
4	210
5	90
6	347
7	43
8	13
9	0
10	40
11	533
12	3056
13	867
14	1258
15	1137
16	1530
17	2022
18	5268
19	12
Hawaii (20)	106
Total # of Base Stations	20330



PCS	MSS	Notes
BS Sidelobe	MSS Main lobe	The vertical discrimination typically present
BS Main Lobe	MSS Sidelobe	BS transmittions over-the-horizon which illuminate the MSS satellite sidelobes. Typically, some over-the-horizon loss factor can be considered due to terrain or above-terrain obstacles such as buildings. A 6-10 dB estimate would be a conservative measure

Figure 4 – PCS Base Station interfering into GSO and nGSO satellites. Worst case coupling typically consists of a main beam-to-sidelobe.

3. The PCS System

The type of terrestrial network used in the analysis is a nationwide narrow-band CDMA system. The network consists of approximately 20,330 base stations distributed across the continental United States (CONUS)[1]. These base stations have been broken down into unique markets and are shown in Figure 3. As a coarse representation of the MSS satellite spot beams, 300-mile circular contours have been overlaid onto the network. The worst case cell in terms of number of base stations is cell # 18 (New York area) which contains 5268 base stations, as shown in Table 1.

[1] The Nextel iDEN network has been used to simulate the PCS network. This network is similar in scale and deployment to the nationwide network proposed for the "G" block at 1990-1995 MHz.

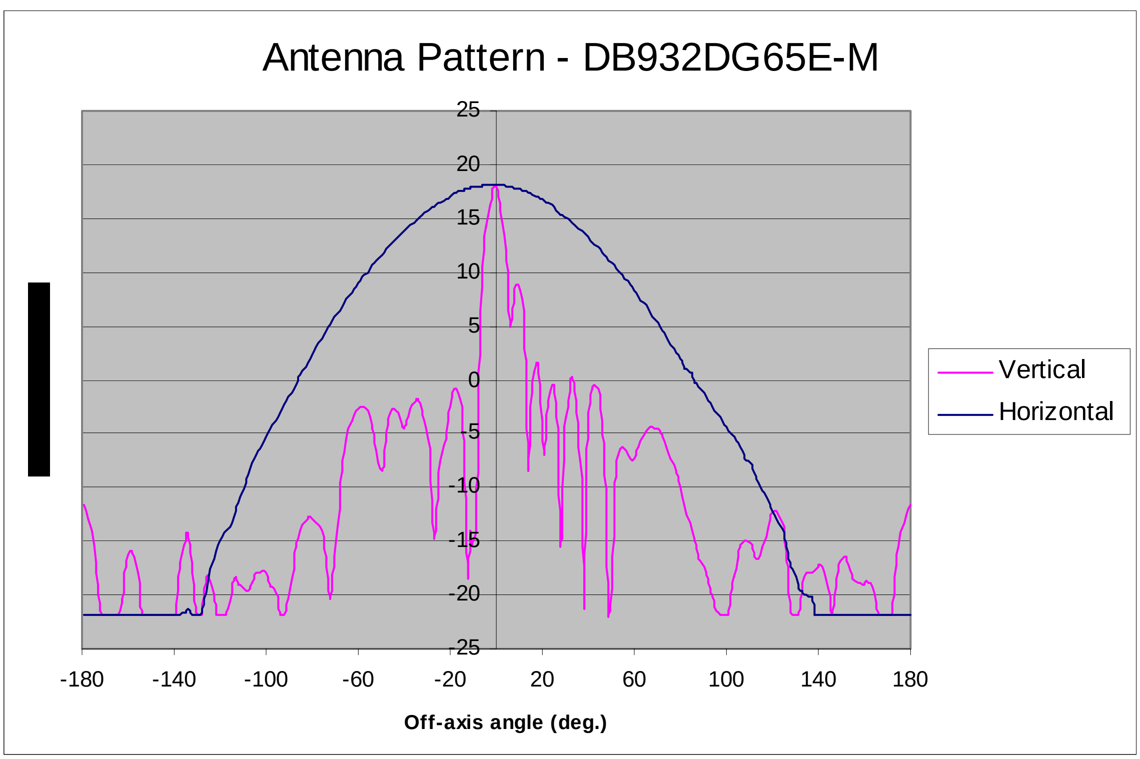
3.1 PCS Base Station

The base station consists of three 65-degree segment antennas. The technical parameters are detailed in Table 2 below. While the antenna chosen for this analysis provides excellent overhead gain suppression Nextel is examining the possibility of using specially designed antennas with maximum sidelobe suppression toward the MSS satellites. Five other antennas were examined and the results for each a presented in Section 8 below.

Table 2 – Nextel Base Station Configuration

Parameter	PCS Base Station	
Number of Antennas Per Station	3	
Beam Arrangement	0, 120, 240	degrees azimuth
	-2	degrees elevation
Transmit Frequencies	1996.25, 1997.5, 1998.75	MHz
Carrier Spacing	1.25	MHz
Transmit Power	43	dBm/carrier
Line Losses	2	dB
Antenna Type	± 45° Diversity Panel Antenna	
Antenna Model	DB932DG65E-M	(see antenna pattern)
Antenna Gain	18.1	dBi
Antenna Beamwidth	65	degrees
Antenna Downtilt Angle	2	degrees
Antenna Height	150	feet

Figure 5 – PCS Antenna Pattern



4. The MSS Satellite Systems

Currently there are five systems authorized to use the MSS spectrum. The five licensees are Terrestar, Boeing, ICO, Iridium, and Celsat. The systems include Geostationary Satellite Orbits (GSO) and non-Geostationary Satellite Orbits (nGSO). The analysis has been performed for both GSO and nGSO. Technical parameters some of the different types are shown in Table 3 below.

Table 3 - MSS System Characteristics

	ICO	Boeing	Terrestar	Iridium	Celsat	
Orbit Type	nGSO	GSO	GSO	GSO	GSO	
Orbital Position	n/a	120	106.5	87.5	121	deg. W.L.
Altitude	10355	35786	35786	35786	35786	km
# Satellites in Constellation	10	1	1	1	1	
# Planes	2	1	1	1	1	
Inclination	45	0.05	0.05	0.05	+/- 6 N-S	deg.
# Spot Beams	163	500	250+	250+	153	
Satellite Rx Antenna Gain	33	51	43	30	43	dBi
Satellite Rx System Noise	500	480	500	500	500	K
User Link Service	TDMA/CDMA	CDMA	CDMA	CDMA	CDMA	

5. Interference Analysis Model

This study is intended to show the level of interfering energy being propagated into proposed satellite systems. The interference model, as briefly described above, consists of calculating the interfering signal levels at the spacecraft receivers.

5.1 Maximum Permissible Level of Interference

A critical piece of information to be derived is the maximum permissible level of interference allowed at the MSS spacecraft. Typically MSS interference studies consider a 6% $\Delta T/T$ degradation. This is a fairly conservative number, it represents an interference-to-noise (I/N) ratio of –12.2 dB, and will be used in this analysis.

The thermal noise floor of the satellite systems can be calculated using kTB. A summary of the system noise and interference noise calculations for a typical GSO and an nGSO system are shown in Table 4 below:

Table 4 – MSS Noise Floor and Maximum Permissible Levels of Interference

MSS Noise Floor Calculation			
	GSO	nGSO	
k	-228.6	-228.6	dBW/K-Hz
T	500	480	K
	27.0	26.8	dB-K
B	1.00E+00	1.00E+00	Hz
	0.00E+00	0.00E+00	dB-Hz
Noise Floor Level	-201.6	-201.8	dBW/Hz
Maximum Permissible Level of Interference			
ΔT/T	6	6	%
kTB (linear)	6.90192E-21	6.6258E-21	
kTB*ΔT	7.31604E-21	7.0234E-21	
ΔT/T	4.14115E-22	3.9755E-22	
Interference Objective	-213.8	-214.0	dBW/Hz

5.2 Interference Calculation Methodology

The interference (I) at the satellite can be calculated by the following formula:

$I = P_{(bs)} + G_{(bs)} – LL - FSL + G_{(s/c)}$

Where:

$P_{(nbs)}$ = RF transmit power of the Base Station, dBW
$G_{(bs)}$ = Gain of the Base Station toward MSS Spacecraft, dBi
FSL = Free space loss to spacecraft, dB
$G_{(s/c)}$ = Gain of spacecraft antenna, dBi
LL = PCS system line losses, dB

As a point of reference, an initial calculation shows that for one base station, transmitting 43 dBm with 2 dB of line losses, and with an antenna gain of -7 dBi toward a GSO satellite with a receive gain of 43 dBi, the interference level (I) will be:

$$I = 43 + -7 – 2 – 190 + 43 = -113 \text{ dBm/1.23 MHz}$$

When correcting for bandwidth and power units dBm to dBW it is the equivalent of:

$$I_0 = -113 - 30 - 60.9 = -203.9 \text{ dBW/Hz}$$

As can be seen if no frequency separation is considered it is possible that one base station operating with nominal transmit characteristics would not meet the interference objective for the GSO and the nGSO case. This suggests that co-channel terrestrial and MSS service is not possible. In our analysis there exists frequency separation and filtering at the transmit and receive sites.

5.3 PCS System Out of Band Filtering

The FCC requires the worst-case out-of-band emission to be 43 + 10Log(P) where P is the PCS base station transmit power in watts. The limit is further specified to be no greater than –13 dBm per MHz outside 1 MHz of the band edge[2].

6. Out-of-Band Emission Interference Calculation

The OOBE interference level can be estimated by calculating the level at the spacecraft from one PCS base station and increasing this number by the worst case number of base stations per cell. As noted above the worst case will occur around the New York area and could contain as many as 5268 stations. Considering the FCC limits on out-of-band emissions the expected interference level will be close to the permissible interference level requirements for most of the proposed satellite systems. Table 5 below calculates the aggregate OOBE levels for a GSO satellite system:

[2] See FCC Rules 24.238

Table 5 – Aggregate Out of Band Levels into GSO Satellite

Single User OOBE Calculations		
Power (base station)	-13.0	dBm/MHz
Gain (base station)	-7.0	dBi[3]
Line losses	-2.0	dB
Free Space Loss to Sat	-190.0	dB
Gain (sat rx)	43.0	dBi
Interference at Satellite	-169.0	dBm/1.00 MHz
Interference at Satellite	-259.0	dBW/Hz
Total Network OOB Calculations (Worst Case)		
Total number of Base Stations	15,804	BS x 3 for each sector
	42.0	dB
Total Interference	-217.0	dBW/Hz
Interference Criteria	-213.8	dBW/Hz
Margin	3.2	dB

As can be seen the OOBE levels will meet the ΔT/T of 6% for the GSO scenario. These values are somewhat conservative based upon the fact that the MSS satellite beams are tighter than the assumed 300-mile radius. These numbers were verified using interference simulation software.

In addition to the above simple analysis a simulation was performed, using the Visualyse software, to determine the worst case aggregated OOBE interference into both a GSO and nGSO satellite systems. For the GSO case the a GSO system with 150 spot beams, a main beam gain of 43 dBi, and a beam pattern with .85 degree 3 dB beamwidth and a ITU-R Appendix 30A Satellite Rx Region 2 Fast Roll-off pattern was used. The GSO satellite had a beam pattern as shown in Figure 6 below. This may not exactly represent any one GSO system, as there are only 150 beams, but the results will be conservative. The simulation results show that the worst-case aggregated OOBE interference into this GSO MSS system is –216.2 dBW/Hz. This value considers all 20,000 base stations and all sectors. The worst-case interference scenario originated from the New York base

[3] The simulation calculated actual antenna gain from each antenna (sector), weighted average for worst case in this cell was equal to –7 dBi. Additionally, four other antenna types were evaluated: they were Andrew Corp DB910TCE-M Omni, EMS Wireless RR65-19-XXDPL5 65 degree sectored 18.5 dBi gain, EMS Wireless RR90-17-XXDPL2 90 degree sectored 16.5 dBi gain, EMS Wireless RR90-18-XXDP 90 degree sectored 17.5 dBi gain, and the Antel BXA-185063/8CF 63 degree sectored 18.5 dBi gain. All results for OOBE were within 3 –4 dB of each other (see Table 8, section 8), the Andrew DB932DG65E-M noted in Table 2 above produced the most conservative results.

station links and the simulation shows that the simplified analysis produces fairly accurate results.

For the nGSO case, a simulation, using the Visualyse software, was prepared and the worst case aggregated OOBE level was calculated to be –207.8 dBW/Hz. The modeling assumptions considered a 10-satellite constellation with 169 beam pattern, also shown in Figure 6 below, and the PCS network distribution as described above in section 3. It should be noted that the nGSO case produced the worst case interference when the main beam or near main-beam of the terrestrial PCS transmitter was pointed to an nGSO satellite far off on the horizon, coupling into the spacecraft's receive antenna sidelobe. An attenuation factor, to consider buildings and other over-the-horizon losses for these low elevation angles could be included. A 6 dB loss factor would be a conservative measure. It should also be noted that the worst-case interference levels will only occur for a relatively small fraction of time. The interfering power will exceed the $\Delta T/T$ criteria of 6% (or –214 dBW/Hz) for less than 0.03% of the time.

The interference levels are such that the FCC limit of 43 + log (P) for adjacent band emissions is, just barely, sufficient. An additional 5-10 dB of OOB filtering may be required to accommodate some of the high gain MSS systems.

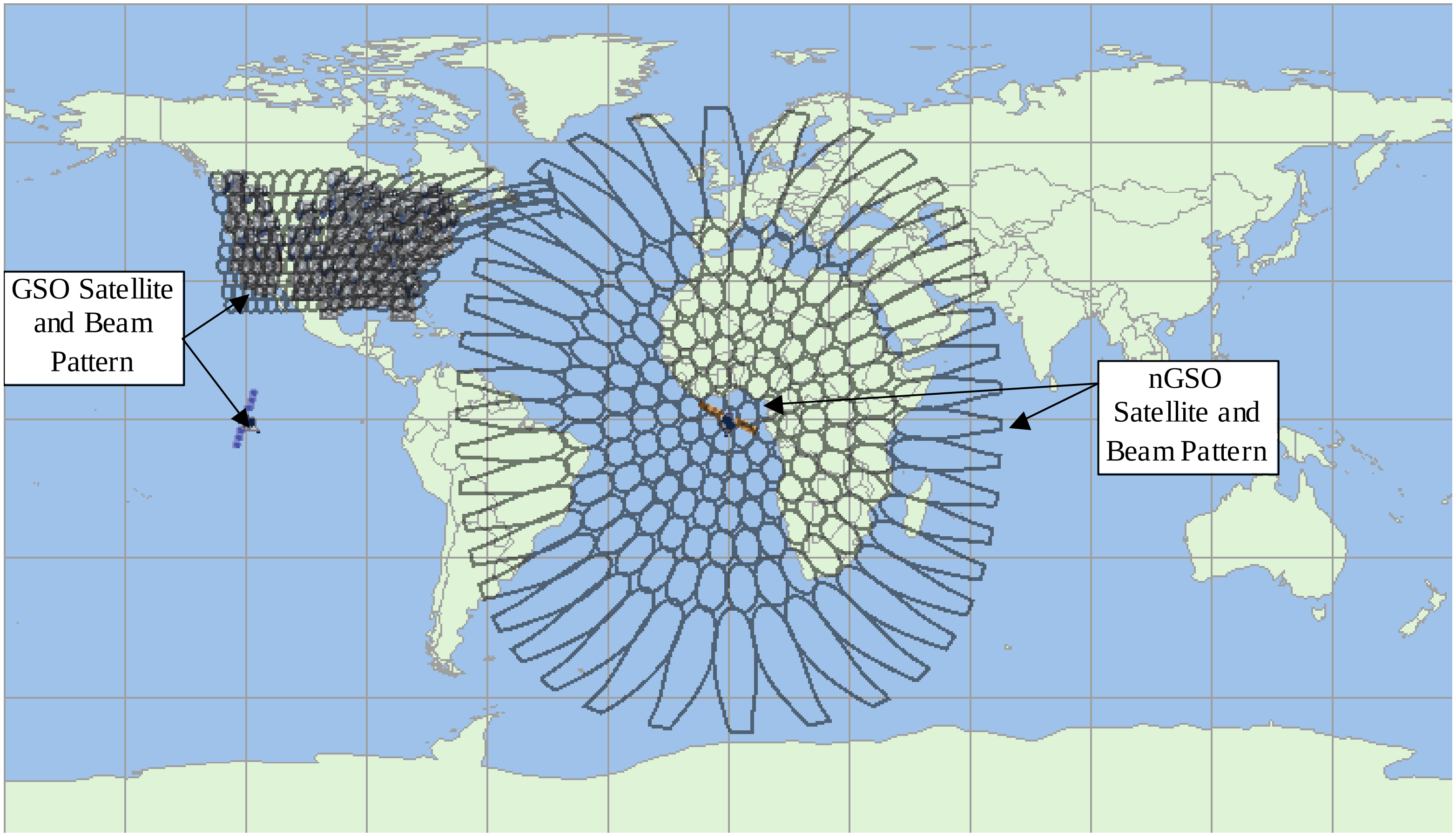


Figure 6 – Representative beam patterns (3dB beamwidth) for GSO system, on right covering CONUS, and nGSO system, center shown for single satellite in constellation at 0^{o} degree azimuth and elevation.

7. Overload at MSS Spacecraft

Another critical factor involves the out-of-band emission filtering at the spacecraft: the ability of the MSS receiver to reject adjacent channel emissions to preclude system overload.

The combination of out-of-band rejection by the PCS base station, the out-of-band rejection by the MSS spacecraft receivers, and the maximum saturated input power level specified at the spacecraft's receive LNA is required. The spacing of the carriers between the services becomes critical as well. The PCS system will have around 625 kHz of guardband at 2000 MHz, as shown in Figure 1. It is not known what the carrier spacing for the MSS systems will be at this time.

The simulation found that the worst-case aggregated levels produced into the GSO satellite in the band 1995-2000 MHz was –102.2 dBW. The worst-case nGSO level calculated was –91.2 dBW but this value exists for a very small percentage of time, the average interference value is at least 20 dB lower. The nGSO case will require a more detailed examination of the allowable time-averaged interference. Using the interfering power levels into a GSO system a summary of the overload potential at the spacecraft can be determined. Considering the following information on a GSO MSS systems, see Table 6 below, an overload calculation has been performed.

Table 6 – Input Saturation Characteristics of MSS Satellite System

Dynamic Range of Satellite Rx LNA	53	dB	This is an assumed value provided to correspond to a an input saturation value of –76 dBm provided after discussions with satellite system design engineers
EIRP of 1 MSS Mobile Terminal	-12	dBW	Assumes a MT EIRP of 23 dBm for CDMA, and 5 dB of fade margin loss
Maximum EIRP allowed for all carriers	41	dBW/1.23 MHz	Sum of first two rows, this is the maximum input EIRP for an LNA with a 53 dB dynamic range
Nominal Free Space Loss	-190	dB	Nominal value for CONUS and GSO satellite at 2 GHz
Satellite Antenna Gain	51	dBi	GSO with approx 22 m receive dish, worst case
Input circuit losses	2	dB	Typical value
Maximum Input to Satellite LNA	-106	dBW	Sum of rows 3 through 6
	-76	dBm	Corresponding maximum input value, as noted above this value was provided after discussion with satellite design engineers as a typical value for satellite receive amplifiers.

An overload calculation is shown in Table 7 below:

Table 7 – Calculation of Interference Overload at GSO Satellite Receiver

Overload Interference at MSS Spacecraft

Free Space Loss:	190.5	dB	GSO satellite
LNA Input Saturation Level	-76	dBm	See Table 5 above
Total Power Level at S/C from PCS Base Stations	-72.2	dBm	Worst case cell derived from simulation
	Single User Level Uplink	Fully Loaded User Level	
# MSS Users	1	15,000	Conservative estimate of number of MSS MT users
MSS User Link EIRP (dBm)	18	59.8	Includes 5 dB of fade margin loss
MSS Level at input to Satellite LNA (dBm)	-129.5	-87.7	Without interference, from other MSS or adjacent band users, input to sat. LNAs is well below saturation
MSS + PCS Level into Satellite LNA (dBm)	-72.2	-72.1	Estimates PCS adjacent band interference to be well above aggregated operating point of MSS users
Margin	3.9	dB	Exceeds estimated value by 3.9 dB

These calculations consider interference from all network base stations into the GSO receiver. The calculations show an overload potential using the above referenced satellite system specifications. It should be noted that the analysis does not consider any mitigation factors, which include:

- Use of base station antenna with better overhead gain suppression
- Base station activation factor (not all base stations will be transmitting simultaneously)
- Antenna downward tilt may be great than 2 degree for a number of base stations

- MSS satellite spot beam may produce more off-axis roll-off than model
- No MSS input amplifier filtering has been considered
- No antenna polarization loss between PCS transmitter and MSS receiver has been considered.

If the MSS systems provide some additional guardband and effective out-of-band rejection then the satellite receiver overload may be mitigated. This issue needs more detailed analysis considering actual MSS bandplans and using more accurate PCS and MSS system parameters.

8. Summary of Results and Conclusions

The results for all PCS base station antenna types is shown in Table 8 below:

Table 8 – Summary of Results for all Base Station Antennas

Antenna Type	Manufacturer	Model #	RF Power	Main Beam Gain	OOB Emissions		Overload	
					GSO	nGSO*	GSO	nGSO*
			(dBm)	(dBi)	dBW/Hz		dBW	
65 deg. sectored	Andrew	DB932DG65E-M	43	18.1	-216.2	-207.1	-102.2	-93.1
65 deg. Sectored	EMS Wireless	RR65-19-XXDPL	43	18.5	-219.3	-205.7	-105.3	-91.7
90 deg. Sectored	EMS Wireless	RR90-18-XXDP	44	17.5	-219.2	-205.8	-105.2	-91.8
90 deg. sectored	EMS Wireless	RR90-17-XXDP	45	16.5	-216.2	-205.2	-102.2	-91.2
63 deg sectored	Antel	BXA-185063/8CF3	43	18.5	-217.5	-206.8	-103.5	-92.8
omni	Andrew	DB910T3CE-M	49	12.1	-217.6	-207	-103.6	-93

* For the nGSO case these values represent peak aggregate interference that would only occur for very small percentages of time, values above $\Delta T/T$ of 6% (-214 dBW/Hz) occur for less than 0.03%. Also these values do not consider terrain or above-terrain path losses.

The study shows that the out-of-band emissions and the receiver overload interference issues need to be closely examined when designing both PCS and MSS in adjacent bands. The OOBE should not pose a problem if the PCS base station transmitters meet or exceed the FCC Rule Part 24.238 limits. Most PCS service providers have base station filters which will provide out-of-band transmission suppression which will exceed the FCC standard by at least 15 dB. The saturation overload is a function of the spacecraft payload design and must accommodate additional interference from operations in the adjacent band that cannot be filtered out. If the maximum input level and dynamic of the LNA is around 58 dB, or greater for high gain MSS system, or if the MSS receiver can provide some out of band rejection within the first 1 MHz of the MSS band edge then satellite receive system overload could be resolved. More detailed analyses considering actual MSS band plans and MSS operational specifications are required.